THE MARIJUANA GROWER'S GUIDE

by Mel Frank and Ed Rosenthal
Typed by Ben Dawson
Revised 1992

NOTE:- Footnotes have been placed in double brackets (()). Numbers throughout refer to bibliography and are sometimes in brackets, sometimes they aren't. All dates are for northern hemisphere only. Comments on pictures are in curly brackets {}. Please distribute this widely so we can all smoke better marijuana. Legalise marijuana.

4 October 1996

Copying this book was a megamission that took about 3 weeks in the September of 1993. Everything in the book has been copied - even the bibliography. The online version of this guide is available at:
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Hyperlinks were added throughout the document for easy navigation. Also the text was formated to be more readable. Alonso Acuña.

August 1999

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- Mellow Gold Staff

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FOREWORD

Marijuana, or cannabis as it is known internationally, is a plant whose presence is almost universal in our world today. Conservative international reports estimate that there are now 300 million cannabis users. Recent reports indicate that 10 percent of the adult population in the United States are regular users, a figure which is probably similar for many countries in Europe. Its use is also widespread in Africa, Asia, many Arab nations, parts of South America and the Caribbean, as well as Australia and New Zealand. In 1978, more than 5.2 million kilograms (12 million pounds) of cannabis were seized by police worldwide. Authorities estimated that this did not exceed 10 percent of the total traffic.

What has been the response of officials around the world to the use of this plant by its citizens? Regrettably, the climate has been one of almost universal repression, hostility and open violence. Despite gains made in the United States and Europe throughout the 1970's, a new wave of ignorance regarding the use of this plant seems to be sweeping the world. Predictably, the United States has sought to export this "neo-Reefer Madness" to other countries. A united Nations sub-commission of drug enforcement officials in the Far East released a report some time ago extremely critical of the efforts of some countries to decriminalize (i.e. remove criminal penalties for possession of a small amount) cannabis. The sub-commission stated that any such reduction of penalties would vastly increase use, and strongly urged that all countries continue to keep strict laws on the books even for possession of cannabis1. Others requested that publicity campaign be conducted in the media against cannabis, and that more funding be given to "scientific" work to prove that cannabis was harmful2.

US officials, alarmed by reports of cannabis use among adolescents (which, although undesirably high, is in fact leveling off), and by political pressure from reactionary elements, have attempted to depict cannabis as the greatest threat since the atomic bomb. The results of this new hysteria have been great confusion among the public and a slowdown in the progress of cannabis law reform. The results have been predictable: in 1979, over 448,000 people were arrested in the USA for cannabis possession, 80 percent for simple possession. The estimated direct arrests cost to our increasingly debt-ridden government was over $600 million. But no one has ever attempted to account for the total cost of the immense law enforcement efforts against cannabis: for the salaries of Drug Enforcement Administration agents and federal and state narcotics agents and support personnel, the cost of incarcerating the thousands of people sentences to jail (estimated at 10 percent of the total arrests, or 48.000 people), the costs of the anti-cannabis media campaign, the secret grants from NSA/CIA for cannabis eradications, and the economic cost to society created by turning law-abiding citizens into criminals. When these factors are taken into consideration, the cost goes into the billions. By contrast, in the eleven states which have enacted decriminalization since 1972, millions of dollars and hundreds of thousands of court, police and administrative work-hours have been saved.

What can the concerned cannabis consumer do to end this climate of hysteria and ignorance? First, we must stress that cannabis legalisation would entail adult use only, and that social and legal restrictions on the use of cannabis would curtail, not increase, use by adolescents. Second, we must educate the public about the genuine effects of cannabis and stress moderate responsible use. This is what we stress about the user of society's legal drugs - alcohol, nicotine and caffeine, and we should take the same approach toward cannabis. Third, the public should be educated about the limits of the law and the rights of citizens; we should not seek to regulate private behaviour through the use of the criminal sanction. Laws

protecting public safety, such as driving while under the influence of any substance, would still be kept on the books.

However, as consumers we have an additional responsibility: we must begin to address the problems of supply and demand. It is essential that we take upon ourselves the task of proposing viable solutions to the current unworkable prohibition.

With this is mind, numerous cannabis reform organizations around the world have begun exploring models for the legalization of cannabis. Under the auspices of the International Cannabis Alliance for Reform (ICAR), an international organization of cannabis law-reform groups, many of these organizations met in Amsterdam, Holland in February, 1980, at the first International Cannabis Legalization Conference to discuss legalization plans and proposals. The many plans presented reflected the various backgrounds and interests of the countries they represented some called for a totally open-market system run by cooperatives, others employed elaborate organizational systems with varying degrees of governmental control, and still others called for total control by the private sector. Emphasis was placed on the need for all groups to develop legalization models suited to their own particular climate and country and that a single, monolithic legalization plan was neither feasible nor desirable.

However, virtually all the plans had one important element in common: every person would have the right to grow cannabis for his or her own personal use. This is the very minimum requirement upon which all legalisation models are based, for this would allow the consumer the chance to remove himself or herself from the black market, whether it be licit or illicit.

This is an essential aspect of cannabis reform: to convince consumers to diversify their sources of supply by growing their own cannabis. Growing cannabis enables one to reduce drastically the costs and at the same time establish a closer relationship with the plant itself. Its amazing adaptability, acquired through centuries of travel to all four corners of the earth, users that it can grow and thrive anywhere there is sunlight and water. By learning the relatively simple techniques involved in cannabis horticulture, the consumer can avoid the illicit market with all its attendant problems, and concentrate on growing the plant itself, on producing and consuming the product of one's own labor, a product which is pure and can be produced at a cost of pennies per ounce.

We must take this step, for just as the nations of the world are seeking energy, self-sufficiency, so now must we seek cannabis self-sufficiency.

The willingness of consumers greatly to diversify their sources has caused tremendous changes in the manner in which cannabis is grown and marketed. Plagued by ridiculously high prices, dangers in purchasing, wild fluctuations in quantity and quality, impurities, and continual police harassment, consumers all over the world are discovering that anyone can grow good cannabis just about anywhere.

In Central and South America, production has increased so rapidly in the last few years that large quantities are now being exported to Europe. Arab countries, traditionally dependent on Lebanon and Syria, are now reporting increasing domestic cultivation attempts. Many countries of Europe, especially the southern countries of Spain, Italy, Portugal and Greece, are reporting cultivation. India noted that both its legal (in the states of West Bengal, Orissa and Madhya Predesh) and illegal (all other states) under a similar scheme. In the Near and Middle East, notably Nepal, Pakistan and Afghanistan, the people are continuing their traditional production of cannabis for local and export use.

Australia, a country whose huge size (roughly that of the US) and relatively sparse population make it virtually ideal for cultivation, reported widespread cultivation and seizures of over 70,000 kilos of cannabis, 2,500 kilos of hashish, and 850,000 plants uprooted in a two-year period between 1977 and 1978. Many people living on Pacific islands such as New Zealand, New Caledonia, Fiji, the Cook Islands and elsewhere have discovered that cannabis will grow very well in their environment; Jamaica and other islands in the Caribbean are also experiencing an increase in cultivation. Recent newspaper reports from that country indicate that as many as 1/2 million Jamaican farmers out of a total population of 2 million may be producing cannabis to satisfy domestic and export demand. The total gross income from the Jamaican cannabis business is estimated to exceed $200 million a year3.

Virtually every country in South America reported at least some cannabis cultivations. In addition to increased production in Colombia, whose 1978 crop was estimated to be worth between $1.5 and $2 billion, other countries are experiencing an increase in cultivation. Over 50,000 acres of cannabis were discovered under cultivation in western Venezuela in 1978. In 1976 in Brazil, 271 kilos of cannabis were reported seized, but the next year increased to 91,207 kilos, and by 1978, authorities seized over 276,000 kilos. Cultivation was also reported in Argentina, Ecuador, Guyana, Surinam and Uruguay. Soviet officials go to inordinate lengths to deny that cannabis-use exists in their country though Russia is known to be a large cannabis producer, and not just for commercial purposes. (Soviet officials reported to the United Nations that they seized only 227 grams of cannabis in the entire country4 in 1978; the few offender were immediately sent to psychiatric hospitals.) In several Eastern European countries the best hashish is knows as "Tashkenti," named for the major city in south-central Russia. Tashkent is ethnically dominated by Turkic tribesmen and shares the Hindu Kush mountain range with Afghanistan.

The key to stability in the cannabis market is clearly domestic production, which offers many economic and social advantages over continued importation.

Domestic varieties offer ease of access and supply, and help to diversify the overall market by offering new products which compete in quality and price with the imported varieties. In addition, they serve to stimulate the local concentrating bulk of the profits in the region in which they were produced. This is a noticeable reversal of the previous consumer-producer relationship, where most of the profits were realized by exporters and middlepersons who operated outside the source country. Expanded domestic production would decrease the influence of these middlepersons and greatly strengthen the overall market.

This book was written to make the consumer aware of how easy (and important) it is to cultivate cannabis. In a clear and simply style, Mel Frank and Ed Rosenthal describe everything you need to know about growing cannabis. By employing some of these simple methods you can greatly reduce your dependence on foreign products and at the same time gain a greater understanding of a plant whose relationship with humanity dates to prehistoric times.

Be fruitful, and multiply...

Bob Pisani Coordinator, International Cannabis Alliance for Reform (ICAR) Philadelphia, PA

Preface

The purpose of this book is to show you how to grow enough marijuana to supply all your family's needs. It doesn't matter where you live, or even if you are growing your first plant, because all the information needed to become a master marijuana farmer in your own home, or in the field, is provided in these pages.

The world has seen an enormous increase in marijuana use in the past ten years. Consequently, many governments have sponsored research in order to understand the nature of the plant as well as its psychoactive compounds - substances that are being smoked or ingested by more then 400 million people all over the world. Before the recent interest, marijuanaphiles had only research papers (mostly on hemp varieties) to glean for information about the plants and their cultivation. Now there are thousands of papers dealing directly with the plants and their use as marijuana. This doesn't mean all is known about marijuana. In fact, much of what is discussed deals with unknown aspects of these ancient and mysterious plants. The mysteries, however, are beginning to unravel.

Our information resources include our personal experience with growing and the experience and knowledge shared with us by marijuana growers all across the country. We also rely on the professional research of many scientists (see the Bibliographic Notes). For the experienced growers, we've included the latest research on increasing potency, some ideas for improving yield and controlling flowering (time of harvest), and also procedures for breeding quality strains suited to a particular growing situation.

Some of the best grass in the world is grown right here in the United States (that is our very own stoned opinion of homegrown gratefully sampled from Hawaii to Maine). You can do it too - it's not magic, and it's not difficult to do. Highly potent plants can be grown indoors, as well as in gardens, fields, and the wilds. Indoor growers must create an environment, whereas outdoor gardeners work within the environment. Following these two approaches to cultivation, this book is divided into separate, parallel parts on indoor and outdoor sections, preceded by some background information on marijuana plants, and followed by general procedures for breeding, harvesting, etc., that are independent of the type of growing site.

Cultivation is not a complicated process, and we hope we don't make it appear difficult. But even if you're a novice when you first sow your seeds, your questions on the plants and their cultivation will become more complex as you gain experience and insight. We hope we have anticipated your questions with solid and clearly stated answers; we intend this book to serve as a guide long after your first reading and harvest.

There are probably as many ways to grow marijuana as there are marijuana farmers. We hope to impart an understanding of the plants and their cultivation, so that you can adapt the knowledge to fit your particular situation - where you live, the land or space available, and the time, energy, and funds at your disposal.

Modest indoor gardens are quite simple to set up and care for. All the materials you'll need are available at nurseries, garden shops, and hardware and lighting stores, or they may be found around the house or streets. The cost will depend on how large and elaborate you make the garden and on whether you buy or scavenge your materials. With a little ingenuity, the cost can be negligible.

It takes about an hour every three or four days to water and tend to a medium-sized indoor garden.

Outdoors, a small patch in your summer garden can supply all your smoking needs with little or no expense. Generally, marijuana requires less care than most other crops, because of its natural tenacity and ability to compete with indigenous weeds. Hardy Cannabis resists mild frost, extreme heat, deluge, and drought. In this country, few diseases attack marijuana; once the plants are growing, they develop their own natural protection against most insects.

In some areas of the country, such as parts of the Midwest and East, the plants may require no more attention than sowing the seeds in spring and harvesting the plants in autumn. But if you're like most growers, you'll find yourself spending more and more time in your garden, watching the tiny sprouts emerge, then following their development into large, lush, and finally resinous, flowering plants.

Nurturing and watching these beautiful plants as they respond can be a humanising experience. Marijuana farmers know their plants as vital living organisms. If you already are a plant grower, you may understand. If not, read through this book, imagining the various decisions you, as grower, would be making to help your plants reach a full and potent maturity. Then make your plans and get started. There's just no reason to pay $50 an ounce for superior smoke when it grows for free. Free, grass, free yourself.

This book is the result of the efforts of many people, each of whom contributed uniquely to its final form and content. First there are the many growers who opened their hearts and gardens to us. Our love and thanks to our friends in California (Calistoga, Calavaras, Humbolt, Orange counties, and the Bay Area), the Umpqua Valley, Oregon, Eastern Colorado, Central Florida, Eastern Massachusetts, Upstate New York, New York City, Atlanta, Hawaii, and Port Antonio, Jamaica. We would also like to thank everyone who wrote and shared their growing experiences with us.

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Chapter One
History and Taxonomy of Cannabis

1.2 CANNABIS AND ANCIENT HISTORY

The ancestors of Cannabis originated in Asia, possibly on the more gentle slopes of the Himalayas or the Altai Mountains to the north. The exact origin, obscured by Stone Age trails the cross the continent, is not known.

We don't know when Cannabis and humanity first met. Given the growth habit of the plant and the curiosity of humanity, such a meeting was inevitable. In the plant world, Cannabis is a coloniser. It establishes new territory when running water or seed-eating animals carry seed to cleared and fertile soil open to the sun. Fertile soil, clear of competing plants, is rare and short-lived in nature, and is commonly caused by catastrophe such as flood or earthslide. Natural dissemination is slow and the plats tend to grow in thick stands by dropping seed about the spread of their branches.

During the Neolithic era, some 10,000 years ago nomadic groups scavenged, hunted, fished, and gathered plants in an unending search for food. The search ended when they learned to plant the native grains (grasses) and developed agriculture. Agriculture requires a commitment to the land and grants a steady food supply which enables people to form permanent settlements. Cannabis and Neolithic bands probably came in contact often as the plants invaded the fertile clearings - the campsites, roadsides, fields and garbage heaps - that occur wherever people live.

In 1926 the Russian botanist Vavilov summarised the observations of his comrade, Sinkaia, on the domestication of hemp by peasants of the Altai Mountains: "1. wild hemp; 2. spreading of hemp from wild centers of distribution into populated areas (formation of weedy hemp); 3. utilisation of weedy hemp by the population; 4. cultivation of hemp."24

The plants which people learn to use help define aspects of their way of life, including perceptions of the world, health, and the directions their technologies and economies flow. The plants you are about to grow are descended from one of the ancient plants that made the transition to civilisation possible.

The earliest cultural evidence of Cannabis comes from the oldest known Neolithic culture in China, the Yang-shao, which appeared along the Yellow River valley about 6,500 years ago (*Cannabis is known to have been used in the Bylony culture of Central Europe (about 7,000 years ago).184). The clothes the people wore, the nets they fished and hunted with, and the ropes they used in the earliest machines were all made of the long, strong, and durable fibre, hemp. This valuable fibre separates from the stem of Cannabis when the stem decays (rets).

In the early classics of the Chou dynasty, written over 3,000 years ago, mention is often made of "a prehistoric culture based on fishing and hunting, a culture without written language but which kept records by tying knots in ropes. Nets were used for fishing and hunting and the weaving of nets eventually developed into clothmaking."8 These references may well be to the Yang-shao people.

As their culture advanced, these prehistoric people replaced their animal skins with hemp cloth. At first, hemp cloth was worn only by the more prosperous, but when silk became available, hemp clothed the masses.

People in China relied on Cannabis for many more products than fibre. Cannabis seeds were one of the

grains of early China along with river barley, millet, and soybeans. The seeds were ground into a meal, or roasted whole, or cooked in porridge. The ancient tombs of China had sacrificial vessels filled with hemp seed and other grains for the afterlife. From prehistoric times there is a continuos record of the importance of hemp seed for food until the first to second century BC when the seed had been replaced by more palatable cereal grains.7 (an interesting note from the Tung-kuan archives (28 AD) records that after a war-caused famine the people subsisted on "wild" Cannabis and soybean.8)

The effects of Cannabis' resinous leaves and flowers did not go unnoticed. The Oen-ts-ao Ching, the oldest pharmacopoeia known, states that the fruits (flowering tops) of hemp, "if taken in excess will produce hallucinations" (literally "seeing devils"). The ancient medical work also says, "If taken over a long term, it makes one communicate with spirits and lightens one's body."9 Marijuana, with a powerful effect on the psyche, must have been considered a magical herb at a time when medical concepts were just being formed. The P[e hat]n-ts'ao Ching, speaking for the legendary Emperor Sh[e hat]n-nung of about 2000 BC, prescribes marijuana preparations for "malaria, beriberi, constipation, rheumatic pains, absent-mindedness, and female disorders."15 Even the Cannabis root found its place in early medicine. Ground to form a paste, it was applied to relive the pain of broken bones and surgery.

New uses were discovered for Cannabis as Chinese civilisation progressed and developed new technologies. The ancient Chinese leaned to mill, heat, and then wedge-press Cannabis seeds to extract the valuable oil, a technique still used in the western world in the twentieth century. Pressed seeds yielded almost 20 percent oil by weight. Cannabis oil, much like linseed oil, could be used for cooking, to fuel lamps, for lubrication, and as the base in paint, varnish, and soap making. After oil extraction, the residue or "hemp cake" still contained about 10 percent oil and 30 percent protein, a nutritious feed for domesticated animals.

Another advancement came with the Chinese invention of paper. Hemp fibres recycled from old rags and fish nets made a paper so durable that some was recently found in graves in the Shense province that predates 100 BC (9) Hemp paper is known for its longevity and resistance to tearing, and is presently used for paper money (Canada) and for fine Bibles.

The ancient Chinese learned to use virtually every part of the Cannabis plant: the root for medicine,; the stem for textiles, rope and paper making; the leaves and flowers for intoxication and medicine; and the seeds for food and oil. Some of the products fell into disuse only to be rediscovered by other people at other times.

While the Chinese were building their hemp culture, the cotton cultures of India and the linen (flax) cultures of the Mediterranean began to learn of Cannabis through expanding trade and from wandering tribes of Aryans, Mongols, and Scythians who had bordered China since Neolithic times.

The Aryans (Indo-Persians) brought Cannabis culture to India nearly 4,000 years ago. They worshipped the spirits of plants and animals, and marijuana played an active role in their rituals. In China, with the strong influence of philosophic and moralistic religions, use of marijuana all but disappeared. But in India, the Aryan religion grew through oral tradition, until it was recorded in the four Vedas, compiled between 1400 and 1000 BC. In that tradition, unlike the Chinese, marijuana was sacred, and the bhangas spirit was appealed to "for freedom of distress" and as a "reliever of anxiety" (from the Atharva Veda).1 A gift from the gods, according to Indian mythology, the magical Cannabis "lowered fevers, fostered sleep, relieved dysentery, and cured sundry other ills; it also stimulated the appetite, prolonged life, quickened the mind, and improved the judgement."15

The Scythians brought Cannabis to Europe via a northern route where remnants of their campsites, from the Altai Mountains to Germany, date back 2,800 years. Seafaring Europe never smoked marijuana extensively, but hemp fibre became a major crop in the history of almost every European country. Pollen analysis dates the cultivation of Cannabis to 400 BC in Norway, although it is believed the plant was cultivated in the British Isles several centuries earlier.2 The Greeks and Romans used hemp for rope and sail but imported the fibre from Sicily and Gaul. And it has been said the "Caesar invaded Gaul in order to tie up the Roman Empire," an allusion to the Romans' need for hemp.

Marijuana, from its stronghold in India, moved westward through Persia, Assyria and Arabs by 500 AD. With the rising power if Islam, marijuana flourished in a popular form as hashish. In 1378, the Emir Soudon Sheikhouni tried to end the use of Indian hashish by destroying all such plants, and imprisoning all users (first removing their teeth for good measure). Yet in a few years marijuana consumption had increased.1

Islam had a strong influence on the use of marijuana in Africa. However, its use is so ingrained in some ancient cultures of the Zambezi Valley that is appearance clearly predated Islam. Tribes from the Congo, East Africa, Lake Victoria, and South Africa smoke marijuana in ritual and leisure. The ancient Riamba cult is still practiced in the Congo. According to the Riamba beliefs, marijuana is a god, protector from physical and spiritual harm. Throughout Africa treaties and business transactions are sealed with a puff of smoke from a yard-long pipe.(15)

With increased travel and trade, Cannabis seed was brought to all parts of the known world by ships and caravans rigged with the fibre of its kind. And when the first settlers came to the Americas, they brought the seed with them.

1.3 CANNABIS AND AMERICAN HISTORY

Like their European forbears, Americans cultivated Cannabis primarily for hemp fibre. Hemp seed was planted in Chile in 1545,(64) Canada in 1606, Virginia in 1611, and in the Puritan settlements in Massachusetts in the 1630s(15). Hemp-fibre production was especially important to the embryonic colonies for homespun cloth and for ship rigging. In 1637, the General Court at Hartford ordered that "every family within this plantation shall procure and plant this present year one spoonful of English hemp seed in some soyle."(12)

Hemp growing was encouraged by the British parliament to meet the need for fibre to rig the British fleets. Partly to dissuade the colonists from growing only tobacco, bounties were paid for hemp and manuals on hemp cultivation were distributed. In 1762, that state of Virginia rewarded hemp growers and "imposed penalties upon those that did not produce it."(2)

The hemp industry started in Kentucky in 1775 and in Missouri some 50 years later. By 1860, hemp production in Kentucky alone exceeded 40,000 tons and the industry was second only to cotton in the South. The Civil War disrupted production and the industry never recovered, despite several attempts by the United States Department of Agriculture to stimulate cultivation by importing Chinese and Italian hemp seed to Illinois, Nebraska, and California. Competition from imported jute and "hemp" (Musa textiles) kept domestic production under 10,000 tons per year. In the early 1900s, a last effort by the USDA failed to offset the economic difficulties of a labour shortage and the lack of development of modern machinery for the hemp industry (64). However, it was legal force that would bring an end to US hemp production.

For thousands of years marijuana had been valued and respected for its medicinal and euphoric properties. The Encyclopaedia Brittanica of 1894 estimated that 300 million people, mostly from Eastern countries, were regular marijuana users. Millions more in both the East and the West received prescription marijuana for such wide-ranging ills as hydrophobia and tetanus.

By the turn of the century, many doctors had dropped marijuana from the pharmacopoeias: drugs such as aspirin, though less safe (marijuana has never kill anyone), were more convenient, more predictable, and more specific to the condition being treated. Pill-popping would become an American institution.

Marijuana was not a legal issue in the United States until the turn of the twentieth century. Few Americans smoked marijuana, and those that did were mostly minority groups. According to author Michael Aldrich, (1) "The illegalisation of Cannabis came about because of who was using it" - Mexican labourers, southern blacks, and the newly subjugated Filipinos.

In states where there were large non-white populations, racist politicians created the myths that marijuana caused insanity, lust, violence and crime. One joint and you were addicted, and marijuana led the way to

the use of "equivalent drugs" - cocaine, opium and heroin. These myths were promoted by ignorant politicians and journalists, who had neither experience nor knowledge of Cannabis, and grew into an anti-marijuana hysteria by the next generation.

For example, the first states to pass restriction on marijuana use were in the Southwest, where there were large populations of migrant workers from Mexico. One of the first states to act was California, which, "with its huge Chicano population and opium smoking Chinatowns, labelled marijuana 'poison' in 1907, prohibited its possession unless prescribed by a physician in 1915, and included it among hard narcotics, morphine and cocaine in 1929." (1)

In marijuana, the mainstream society found a defenceless scapegoat to cover the ills of poverty, racism, and cultural prejudice. San Franciscans "were frightened by the 'large influx of Hindoos ... demanding Cannabis indica' who were initiating 'the whites into their habit.'" (11) Editorialists heightened public fears with nightmarish headlines of the "marijuana menace" and "killer weed," and fear of Cannabis gradually spread through the West. By 1929, 16 western states had passed punitive restrictions governing marijuana use.

{Figure 5. (Sample -- Warning card to be placed in R. R. Trains, Buses, Street Cars, etc.)
Beware! Young and Old - People in All Walks of Life!
This {joint} may be handed you by the friendly stranger.
It contains the Killer Drug "Marihuana" -- a powerful narcotic
in which lurks Murder! Insanity! Death!
WARNING!
Dope peddlers are shrewd! They may put some of this drug in the {teapot}
or in the {cocktail} or in the tobacco cigarette.
WRITE FOR DETAILED INFORMATION, ENCLOSING 12 CENTS IN
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Marijuana was not singled out be anti-drug campaigners. During this time, Congress not only banned "hard" narcotics, but also had prohibited alcohol and considered the prohibition of medical pain killers and even caffeine.

The Federal Bureau of Narcotics was established in 1930 with Harry Anslinger as its first commissioner. During the first few years of operation, the bureau minimised the marijuana problem, limited mostly to the Southwest and certain ghettos in the big cities of the East. However, the bureau was besieged with pleas from local police and sheriffs to help with marijuana problems. The FBN continued to resist this pressure, because Commissioner Anslinger had serious doubts as to whether federal law restricting marijuana use could be sustained as constitutional. Further, FBN reports indicate that the bureau did not believe that the marijuana problem was as great as its public reputation. Control of the drug would also prove extremely difficult, for as Anslinger pointed out, the plant grew "like dandelions." (11)

The joblessness and misery of the depression added impetus to the anti-marijuana campaign. This came about indirectly, by way of focusing public sentiment against migrant and minority workers who were blamed for taking "American" jobs. Much of this sentiment grew out of cultural and racial prejudice and was supported by groups such as Key Men of America and the American Coalition. The goal of these groups was to "Keep America American."

However, by 1935 almost every state had restricted marijuana use, and local police and influential politicians had managed to pressure the FBN to seek a federal marijuana law. The constitutional question could be circumvented by cleverly tying restrictions to a transfer tax, effectively giving the federal government legal control of marijuana.

With this new tack, the FBN prepared for congressional hearings on the Marijuana Tax Act so that passage of the bill would be assured. Anslinger and politicians seeking to gain from this highly emotional issue railroaded the Marijuana Tax Act through the 1937 Congress. Anslinger made sure that "the only information that they (the congressmen) has was what we would give them at the hearings." (11) No users were allowed to testify in pot's defence, and doctors and scientists were ridiculed for raising contrary views (16). The new federal law made both raising and use of the plant illegal without the purchase of a hard-to-acquire federal stamp. The FBN immediately intensified the propaganda campaign against marijuana and for the next generation, the propaganda continued unchallenged.

The marijuana hysteria also ended any hopes for a recovery of the hemp industry. What had been needed was a machine that would solve the age-old problem of separating the fibre from the plant stem, an effort which required considerable skilled labour. The machine that could have revolutionised hemp production was introduced to the American public in the February 1938 edition of Popular Mechanics. But the Marijuana Tax Act has been passed four months earlier, and the official attitude toward all Cannabis is best illustrated by this quote from Harry J. Anslinger, commissioner of the Federal Bureau of Narcotics: "Now this (hemp) is the finest fibre known to man-kind, my God, if you ever have a shirt made of it, your grandchildren would never wear it out. You take Polish families. We'd go in and start to tear it up and the man came out with his shotgun yelling, 'These are my clothes for next winter!'" (2)

During the war years, after the Japanese had cut off America's supply of manila hemp, worried officials supplied hemp seed and growing information to Midwestern farmers. In Minnesota, Iowa, Illinois, and Wisconsin, hemp farmers showed their wartime spirit by producing over 63,000 tons of hemp fibre in 1943.

Unlike many of our ancient domesticated plants, Cannabis never lost its colonising tendencies or ability to survive without human help. Cannabis readily "escapes" cultivated fields and may flourish long after its cultivation is abandoned. However, Cannabis always keeps in contact by flourishing in our waste areas - our vacant fields and lots, along roads and drainage ditches, and in our rubbish and garbage heaps. Perhaps it awaits discovery by future generations. The cycle has been repeated many times.

States that once supported hemp industry are now dotted with stands of escaped weedy hemp. Weedy hemp grows across the country, except in the Southwest and parts of the Southeast. Distribution is centered heavily in the Midwest. Most of these plants are descended from Chinese and European hemp strains that were bred in Kentucky and the grown in Midwestern stated during World War II. But some weed patches, such as in Kentucky and Missouri, go back perhaps to revolutionary times.

The Anslinger crusades that continued through the sixties are a fine example of government propaganda and control of individual lives and beliefs. We still feel the ramifications in our present laws and in the fear-response to marijuana harboured by many people who grew up with Anslingian concepts. Poor Cannabis, portrayed as a dangerous narcotic that would bring purgatory upon anyone who took a toke - violence, addiction, lust, insanity - you name it, and marijuana caused it. All it ever did to us was get us stoned ... things slowed down a bit ... enough to stop and look around.

{Figure 6. A weedy hemp stand in Nebraska.}

Hopefully, we are living in the last years of the era of illegal marijuana and the persecution of this plant. Cannabis is truly wondrous, having served human needs for, perhaps, 10,000 years. It deserves renewed attention not only for its chemical properties, but also as an ecologically sensible alternative for synthetic fibres in general and especially wood-pulp paper. May Cannabis be vindicated.

1.4 Cannabis: Species or Varieties

The 10,000-year co-evolution of Cannabis and humanity has had a profound impact on both plant and humans. Cannabis has affected our cultural evolution; we have affected the plant's biological evolution.

From small populations of ancient progenitors, hundreds of varieties or strains of Cannabis have evolved. These variations can be traced to human acts, both planned and accidental.

Ancient farmers, knowing that like begets like, selected Cannabis for certain characteristics to better suit their needs. With the need for fibre, seeds from plants with longer stems and better fibres were cultivated. Gradually, their descendants became taller, straight-stemmed, and had a minimum of branches. Some farmers were interested in seed and oil. They developed large-seeded, bushy plants that could bear an abundance of seeds. Marijuana farmers interested in potency selected plants that flowered profusely with heavy resin and strong psychoactive properties.

The subsequent variations in Cannabis are striking. In Italy, where hemp fibre supports a major textile and paper industry, some fibre varieties grow 35 feet in a single season. Other Italian varieties may reach only five or six feet in height, but have slender, straight stems that yield a fibre of very fine quality. In Southeast Asia, some marijuana plants grow only four feet or less, yet these are densely foliated and heavy with resin. Other varieties of marijuana grow 15 to 20 feet in a season and yield over a pound of grass per plant.

Breeding plants is a conscious act. The plant's evolution, however, has also been affected by its introduction to lands and climates different from its original home. Whether plants are cultivated or weeds, they must adapt to their environment. Each new country and growing situation presented Cannabis with new circumstances and problems for survival. The plants have been so successful at adapting and harmonising with new environments that they are now considered the most widely distributed of cultivated plants. (45)

In French, Cannabis is sometimes called "Le Chanvre troumper" or "tricky hemp," a name coined to described its highly adaptable nature. The word adaptable actually has two meanings. The first refers to how a population of plants (the generic pool) adjusts to the local environment over a period of generations. (The population is, in practice, each batch of seeds you heave, or each existing stand or field.) For instance, a garden with some plants that flower late in the season will not have time to seed in the north. The next year's crop will come only from any early seeding plants. Most of them will be like their parents and will set seed early. (See section 18.)

Adaptable is a term that also applies to the individual living plant (phenotype) and, in practical terms, means that Cannabis is tenacious and hardy -- a survivor among plants. It thrives under a variety of environmental conditions, whether at 10,000 feet in the Himalayas, the tropical valleys of Colombia, or the cool and rainy New England coast.

Through breading and natural selection, Cannabis has evolved in many direction. Botanically and historically, the genus is so diverse that many growers are confused by the mythology, exotic names, and seeming contradictions that surround the plants. Many inconsistencies are explained by understanding how variable Cannabis is. There are hundreds of wild, weedy, and cultivated varieties. Cultivated varieties may be useful for only hemp, oil, or marijuana. "Strains," "varieties," "cultivars," "chemovars," or "ecotypes" differ widely in almost every apparent characteristic. Varieties range from two to 35 feet tall; branching patterns run from dense to quite loose, long (five or six feet) or short (a few inches). Various branching patterns form the plant into shapes ranging from cylindrical, to conical, to ovoid, to very sparse and gangly. The shape and colour of leaves and stems, seeds, and flowering clusters are all variable characteristics that differ among varieties. Life cycles may be as short as three months, or the plants may hang on to life for several years. Most importantly, different varieties provide great variations in the quality and quantity of resin they produce, and hance in their psychoactive properties and value as marijuana.

The taxonomy (ordering and naming) of Cannabis has never been adequately carried out. Early research placed the genus Cannabis within the Families of either the Moraceae (mulberry) or the Urticaceae (nettle). Now there is general agreement that the plant belongs in a separate family, the Cannabaceae, along with one other genus, Humulus, the hops plant. (See section on Grafting in section 18.)

A modern Scheme for the phylogeny of Cannabis would be:

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Subdivision     Angiospermae (flowering plants)
Class   Dicotyledoneae (dicots)
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Order   Uriticales (nettle order)
Family  Cannabaceae (hemp family)
Genus   Cannabis (hemp plant)
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Below the genus level, there is no general agreement on how many species should be recognised within Cannabis. The Cannabis lineage has not been possible to trace after thousands of years of human intervention.

Most research refers to Cannabis as a single species - Cannabis sativa L. (The word Cannabis comes from ancient vernacular names for hemp, such as the Greek Kannabis; sativa means "cultivated" in Latin; L. stands for Linnaeus, the botanical author of the name.) But some botanists who are studying Cannabis believe there are more than one species within the genus.

Richard Schultes, for example, describes three separate species (see Box A) based on variations in characteristics believed not to be selected for by humans (natural variations) such as seed colour and abscission layer (scar tissue on the seed which indicates how it was attached to the stalk).

BOX A
Schultes' Key as it appears in Harvard Botanical Museum Leaflets (45)

Cannabis Sativa
1. Plants usually tall (five to 18 feet), laxly branched; akenes ((Akene (or Achene) is the botanical name for the fruit of Cannabis. In Cannabis, the fruit is essentially the seed.)) smooth, usually lacking marbled pattern on outer coat, firmly attached to stalk and without definite articulation.

Cannabis Indica
1A. Plant usually small (four feet or less), not laxly branched; akenes usually strongly marbled on outer coat, with a definite abscission layer, dropping off at maturity.
2. Plants very densely branched, more or less conical, usually four feet tall or less; abscission layer a simple articulation at base of akene.

Cannabis ruderalis ((Limited to parts of Asia.))
2A. Plants not branched or very sparsely so, usually one to two feet at maturity. Abscission layer forms a fleshly carbuncle-like growth at base of akene.

Ideally, the classification of living things follows a natural order, reflecting relationships as they occur in nature. Species are groups of organisms that are evolving as distinct units. Biologically, the evolutionary unit is the population, a population being a group of freely inbreeding organisms. Living things don't always fit neatly into scientific categories. And the meaning of species changes with our understanding of life and the evolutionary processes. Often, the definition of species will depend on the particular being studied.

A traditional way of defining separate species is that off-spring that result cannot reproduce successfully. As far as is known, all Cannabis plants can cross freely, resulting in fully fertile hybrids (107). But growth habit and actual gene exchange are important considerations in plant taxonomy. If different populations never come in contact, then there is no pressure for them to develop biological processes to prevent them mixing. Cannabis is pollinated by the wind. Although wind may carry pollen grains hundreds of miles, almost all pollen falls within a few feet of the parent plant. The chance of a pollen grain fertilising a tiny female flower more than 100 yards away is extremely small (201). Hence, separate stands or fields of Cannabis (populations) are quite naturally isolated. For Cannabis, the fact that populations are isolated by distance is not sufficient grounds for labelling them separate species, nor is successful hybridisation reason enough to group all populations as one species.

The species question and Cannabis mythology are complicated by the plant's ability to rapidly change form and growth habits. These changes can be measured in years and decades, rather than centuries or millennia.

The fact that a pollen grain does occasionally fertilise a distant flowers leads to a process called introgression. Introgression means that new genes (new variations and possible variations) are incorporated into the population via the foreign pollen. This crossing between populations leads to an increase in variation within the population, but a decrease in the differences between the populations. Although introgression confuses the species question, it also adds to the plant's adaptable nature by providing a resource for adaptive variations. In other words, Cannabis has been around. The plants have a rich and varied history of experience, which is reflected in their variety and adaptive nature.

If breeding barriers do not exist, species are often delimited by natural differences in morphology (structure or appearance). The natural variations on which Schultes' key is based are actually affected by contact with farmers. For instance, seeds which drop freely from the plant are less likely to be collected and sown by the farmer, so that cultivated Cannabis may eventually develop a different type of abscission layer than when wild or weedy.

Seed colour and pattern are affected naturally by the need for camouflage. Under cultivation this natural selection pressure would not be the same. Many farmers select seeds by colour, believing the darkest are the best developed. In other words, there are serious problems with this limited approach to categorising species in Cannabis. This does not go unrecognised by Dr. Schultes, and the key represents a starting point. However, species should represent distinct groups within a genus, and populations with intermediate characteristics should be the exception. When you grow marijuana, you'll find that most varieties do not fit into any of these categories, but lie somewhere between. The majority of the marijuana from the Western Hemisphere would follow this description: plants tall (eight to 18 feet); well-branched; akenes usually strongly marbled; base of the seed sometimes slightly articulated.

Other characteristics, such as variations on wood anatomy (17) and leaf form (28), have been suggested for delimiting Cannabis species. However, wood anatomy, like stem anatomy, can be seriously affected by selection for hemp in particular, but also by selection for marijuana and seed. Wood anatomy also depends on the portion of the stem examined and on the arrangement of leaves (phyllotaxy), which, in turn, is influenced by light levels, photoperiod, and the physiological development of the plant.

Most Cannabis plants have compound leaves with seven to nine blades or leaflets per leaf. Occasionally, varieties are seen where all the leaves have only one to three blades (monophyllous). Such plants sometimes arise from varieties with compound leaves. The factor is genetic, but carries little weight for the separation of species.

Human selection for particular traits can powerfully alter plants. Sex vegetables - cabbage, cauliflower, brussel sprouts, broccoli, kale, and kohlrabi - are all descended from a single wild species of mustard herb, Brassica oleracea (216). Human preference for particular parts of the plant led to their development. All six are still considered one species.

Any classification of species in Cannabis, based solely on morphological grounds, will prove difficult to justify with our present knowledge of the plant. At this time it seems that all Cannabis should be considered one species, Cannabis sativa L.

{Figure 7. Common marijuana leaf with seven blades (Colombian)}
{Figure 8. Four leaf types from Colombian marijuana varieties}
{Figure 9. Leaf blades from Figure 8.}

The debate on whether there is more than one species has been intense, for the issue has legal implications. Many laws specifically prohibit only Cannabis sativa. Presumably other species would not be prohibited. However, in the United States, this argument was recently dismissed when tested in a California court. The court upheld the argument that the law's intent is clear, although it may be questionable botanically: under law all Cannabis are regarded alike.

Luckily, the controversy over the number of species is of no more than academic interest to the marijuana grower. The most important characteristic to enthusiasts is the quality or potency of the grass they'll grow.

Potency is mostly a factor of heredity. The quality of the grass you grow depends on how good its parents were, so choose seeds from the grass you like best.

The environment has an impact, too, but it can only work on what is contained in the seed. A potent harvest depends on an environment which encourages the seed to develop to a full and potent maturity. The way to begin is to find the most potent grass you can; then you will have taken the first step.

CHAPTER 2
CANNABINOIDS: THE ACTIVE INGREDIENTS OF MARIJUANA

Cannabis is unique in many ways. Of all plants, it is the only genus known to produce chemical substances known as cannabinoids. The cannabinoids are the psychoactive ingredients of marijuana; they are what get you high. By 1974, 37 naturally occurring cannabinoids had been discovered 115,118. Most of the cannabinoids appear in very small amounts (less than .01 percent of total cannabinoids) and are not considered psychoactive, or else not important to the high. Many are simply homologues or analogues (similar structure or function) to the few major cannabinoids which are listed.

1. (-)-{triangle}9-trans-tetrahydrocannabinol ((There are several numbering systems used for cannabinoids. The system in this book is most common in American publications and is based on formal chemical rules for numbering pyran compounds. Another common system is used more by Europeans and is based on a monoterpenoid system which is more useful considering the biogenesis of the compound.)) This (delta-9 THC) is the main psychotomimetic (mindbending) ingredient of marijuana. Estimates state that 70 to 100 percent (121) of the marijuana high results from the delta-9 THC present. It occurs in almost all Cannabis in concentration that vary from traces to about 95 percent of all the cannabinoids in the sample. In very potent varieties, carefully prepared marijuana can have up to 12 percent delta-9 THC by dry weight of the sample (seeds and stems removed from flowering buds). (("Buds" of commercial marijuana is the popular name given to masses of female flowers that form distinct clusters.))

Delta-8 THC - This substance is reported in low concentration, less than one percent of the delta-9 THC present. Its activity is slightly less than that of delta-9 THC. It may be an artefact of the extraction/analysis process. Here we refer to delta-9 THC and delta-8 THC as THC.

2. Cannabidiol - CBD also occurs in almost all varieties. Concentration range from nil (119,138), to about 95 percent of the total cannabinoids present. THC and CBD are the two most abundant naturally occurring cannabinoids. CBD is not psychotomimetic in the pure form (192), although it does have sedative, analgesic, and antibiotic properties. In order for CBD to affect the high, THC must be present in quantities ordinarily psychoactive. CBD can contribute to the high by interacting with THC to potentiate (enhance) or antagonise (interfere or lessen) certain qualities of the high. CBD appears to potentiate the depressant effects of THC and antagonise is excitatory effects (186). CBD also delays the onset of the high (183) but can make it last considerably longer (as much as twice as long). (The grass takes a while to come on but keeps coming on.) Opinions are conflicting as to whether it increases or decreases the intensity of the high, "intensity" and high" being difficult to define. Terms such as knock-out or sleepy, dreamlike, or melancholic are often used to describe the high from grass with sizeable proportions of CBD and THC. When only small amounts of THC are present with high proportions of CBD, the high is more of a buzz, and the mind feels dull and the body de-energised. {See Figure 11 to 16 for chemical structure in monochrome bitmap format.}

3. Cannabinol - CBN is not produced by the plant per se. It is the degradation (oxidative) product of THC. Fresh samples of marijuana contain very little CBN but curing, poor storage, or processing such as when making hashish, can cause much of the THC to be oxidised to CBN. Pure forms of CBN have at most 10 percent of the psychoactivity of THC (192). Like CBD, it is suspected of potentiating certain aspects of the high, although so far these affects appear to be

slight (183,185). CBN seems to potentiate THC's disorienting qualities. One may feel more dizzy or drugged or generally untogether but not necessarily higher. In fact, with a high proportion of CBN, the high may start well but feels as if it never quite reaches its peak, and when coming down one feels tired or sleepy. High CBN in homegrown grass is not desirable since it represents a loss of 90 percent of the psychoactivity of its precursor THC.

4. Tetrahydrocannabivarin - THCV is the propyl homologue of THC. In the aromatic ring the usual five-carbon pentyl is replaced by a short three-carbon propyl chain. The propyl cannabinoids have so far been found in some varieties originating from Southeast and Central Asia and parts of Africa. What are considered some very potent marijuana varieties contain propyl cannabinoids. In one study, THCV made up to 48.23 percent (Afghanistan strain) and 53.69 percent (South Africa) of the cannabinoids found (136). We've seen no reports on its activity in humans. From animal studies it appears to be much faster in onset and quicker to dissipate than THC (181). It may be the constituent of one- or two-toke grass, but its activity appears to be somewhat less than that of THC.

The propyl cannabinoids are a series corresponding to the usual pentyl cannabinoids. The counterpart of CBD is CBDV; and of CBN, CBV. There are no reports on their activity and for now we can only speculate that they are similar to CBD and CBN. Unless noted otherwise, in this book THC refers collectively to delta-9 THC, delta-8 THC, and THCV.

5. Cannabichromene - CBC is another major cannabinoid, although it is found in smaller concentrations than CBD and THC. It was previously believed that is was a minor constituent, but more exacting analysis showed that the compound often reported as CBD may actually be CBC (119,137). However, relative to THC and CBD, its concentration in the plants is low, probably not exceeding 20 percent of total cannabinoids. CBC is believed not to be psychotomimetic in humans (121); however, its presence in plants is purportedly very potent has led to the suspicion that it may be interacting with THC to enhance the high (137). Cannabicyclol (CBL) is a degradative product like CBN and CBV (123). During extraction, light converts CBC to CBL. There are no reports on its activity in humans, and it is found in small amounts, if at all, in fresh plant material.

2.2 Cannabinoids and the High

The marijuana high is a complex experience. It involves a wide range of psychical, physical, and emotional responses. The high is a subjective experience based in the individual - one's personality, mood, disposition, and experience with the drug. Given the person, the intensity of the high depends primarily on the amount of THC present in the marijuana. Delta-9 THC is the main ingredient of marijuana and must be present in sufficient quantities for a good marijuana high. People who smoke grass that has very little cannabinoids other then delta-9 THC usually report that the high is very intense. Most people will get high from a joint having delta-9 THC of .5 percent concentration to material. Grass having a THC concentration of three percent would be considered excellent quality by anyone's standards. In this book, for brevity, we use potency to mean the sum effects of the cannabinoids and the overall high induced.

Marijuana (plant material) is sometimes rated more potent that the content of delta-9 THC alone would suggest. It also elicits qualitatively different highs. The reasons for this have not been sorted out. Few clinical studies with known combinations of several cannabinoids have been undertaken with human subjects. This field is still in its infancy. So far, different highs and possibly higher potency seem to be due to the interaction of delta-9 THC and other cannabinoids (THCV,CBD,CBN, and possibly CBC). Except for THCV, in the pure form, these other cannabinoids do not have much psychoactivity.

Another possibility for higher potency is that homologues of delta-9 THC with longer side chains at C-3 (and higher activity) might be found in certain marijuana varieties. Compounds with longer side chains have been mode in laboratories and their activity is sometimes much higher, with estimates over 500 times that of natural delta-9 THC (55,113,191). Compounds besides THCV with shorter chains (methyl

(139) and butyl (118)) in this position have been found in small amounts in some marijuana samples, indicating that variations do exist. However, this is not a very likely explanation. More likely, THCV is more prevalent in marijuana than supposed and probably had additive or synergistic effects with delta-9 THC.

The possibility that there are non-cannabinoids that are psychoactive or interacting with the cannabinoids has not been investigated in detail. Non-cannabinoids with biological activity have been isolated from the plants, but only in very small quantities (181). None are known to be psychotomimetic. However, they may contribute to the overall experience in non-mental ways, such as the stimulation of the appetite.

Different blends of cannabinoids account for high of different qualities. The intensity of the high depends primarily on the amount of delta-9 THC present and on the method of ingestion. A complex drug such as marijuana affects the mind and body in many ways. Sorting out what accounts for what response can become quite complex. The methodology to isolate and test the different cannabinoids now exists. The National Institute of Mental Health (NIMH) is funding research on the pharmacology of marijuana. However, such research is paltry, considering that over 30 million people in the United States use the crude drug. Much more research is needed before definite understanding of the cannabinoids and the high is attained.

When the legal restriction are removed, marijuana will probably be sold by particular blends of cannabinoids and standard amounts of delta-9 THC. Synthetic marijuana will probably be made with homologues of delta-9 THC that have much higher activity than the natural form. For now, without access to a lab, you must be satisfied with your own smoking evaluation (for research purposes only), ultimately the most important criterion any way.

2.3 Resin and Resin Glands

Many people consider potency and resin concentration synonymous. People hear of plants oozing or gushing with copious resin, and the image is of resin flowing in the plant like the latex of a rubber tree or the sap of a maple tree. But these visions are just pipe dreams.

It is quite possible to have a resinous plant with little potency or a plant with little apparent resin which is very potent. Potency depends primarily on the concentration of THC in the plant material. Many more substances besides the cannabinoids make up the crude resin of Cannabis. Preparations such as ghanja or hashish are roughly about one-third by weight non-psychoactive water-soluble substances and cellular debris. Another third is non-psychoactive resins such as phenoloic and terpenoid polymers, glycerides, and triterpenes. Only one-fourth to one-third is the cannabinoids. In many Cannabis plants, THC may be only a very small percentage of the total cannabinoids. ((These figures are very approximate. Actual percentages depend on sample material, processing, and extraction procedures. See Table 8 and 9 for percentages of THC in hashish.)) The remainder (5 to 10 percent) of the resin will be essential oils, sterols, fatty acids, and various hydrocarbons common to plants.

Table 8 - Seized Hashish (a)

COUNTRY IN WHICH SEIZED	Range of Percentage of THC	CBD
Greece	1 - 15.8	1.4 - 11.1
Nepal	1.5 - 10.9	8.8 - 15.1
Afghanistan	1.7 - 15	1.8 - 10.3
Pakistan	2.3 - 8.7	6.8(b)

a Figures compiled from many sources.
b Only one figure reported

Table 9 - Relative Percentages of Major Cannabinoids from Hashish and Resin Preparations.

COUNTRY	Average Percentages of THC	CBD	CBN
Afghanistan	52	36	12
Burma	15.7	16.3	68
Jamaica	77.5	9.1	13.4
Lebanon	32.2	62.5	5.3
Morocco	55	34.2	10.8
Nigeria	53.7	9.3	37
Pakistan	35.7	48.3	16.1
South Africa	75.6	8.4	16

a Each row sums to 100%

_TABLE 9

The cannabinoids basically do not flow in the plant, nor are they the plant's sap. About 80 to 90 percent of the cannabinoids are synthesised ad stored in microscopic resin glands that appear on the outer surfaces of all plant parts except the root and seed. the arrangement and number (concentration) of resin glands vary somewhat with the particular strain examined. Marijuana varieties generally have more resin glands, and they are larger then resin glands on non-drug varieties.

Although resin glands are structurally diverse, they are of three basic types. The bulbous type is the smallest (15-30 um ((um is the symbol for a micrometer (or micron), equal to 1/1,000,000 of a meter, or approximately 1/25,000 of an inch.)) or about .0006 to .0012 inches). From one to four cells make up the "foot" and "stalk," and one to four cells make up the "head" of the gland (25). Head cells secrete a resin - presumably cannabinoids - oils, and related compounds which accumulate between the head cells and the outer membrane (cuticle). When the gland matures, a nipple-like outpocket may form on the membrane from the pressure of the accumulating resin. The bulbous glands are found scattered about the surfaces of the above-ground plant parts.

The second type of gland is much larger and more numerous than the bulbous glands. The are called "capitate," which means having a globular-shaped head. On immature plants, the heads lie flush or appear not to have a stalk and are called "capitate sessile." They actually have a stalk that is one cell high, although it may not be visible beneath the globular head. The head is composed of usually eight, but up to 16 cells, that form a convex rosette. These cells secrete a cannabinoid-rich resin which accumulates between the rosette and its outer membrane. This gives it a spherical shape, and the gland measures from 25 to 100 um across. In fresh plant material about 80 to 90 percent of their contents will be cannabinoids, the rest primarily essential oils (146).

During flowering the capitate glands that appear on the newly formed plant parts take on a third form. Some of the glands are raised to a height of 150 to 500 um when their talks elongate, possibly due to their greater activity. The stalk is composed mostly of adjacent epidermal tissue. These capitate-stalked glands appear during flowering and form their densest cover on the female flower bracts. They are also highly concentrated on the small leaves that accompany the flowers of fine marijuana varieties. Highest concentration is along the veins of the lower leaf surface, although the glands may also be found on the upper leaf surface on some varieties. The male flowers have stalked glands on the sepals, but they are smaller and less concentrated than on the female bracts. Male flowers form a row of very large capitate glands along the opposite sides of anthers.

Capitate-stalked resin glands are the only ones visible without a microscope. To the naked eye, this covering of glands on the female flower bracts looks like talcum or dew sprinkled on a fuzzy surface. With a strong hand lens, the heads and stalks are distinct. Resin glands also can be seen on the anthers of the male flowers and on the undersides of the small leaves the intersperse the flower clusters.

{Figure 17. Upper surface of a small leaf, showing stalked glands.}
{Figure 18. Resin glands on a stem lie close to the surface beneath the cystolith hairs. Hairs always point in direction of growing shoots.}

Resin glands are not visible until flowers form. The more obvious covering of white hairs seen on stems,

petioles, and leaves are not resin glands. They are cystolith hairs of carbonate and silicate which are common to many plants. These sharp-pointed hairs afford the plant some protection from insects and make it less palatable to larger, plant-eating animals.

In India, to make the finest quality hashish (nup), dried plants are thrashed over screens. Gland heads, stalks and trichomes collect in a white to golden powder which is then compressed into hashish (for hashmaking search section 21 for "hash").

Resin rarely accumulates in the copious quantities people would lead you to believe. Actually, the plants form a cover of resin glands rather than a coating of resin. Usually this is no more apparent than for the female flowers to glisten with pin-points of light and for the leaves and stems to feel a bit sticky when you run your fingers over them.

On some fine marijuana strains, resin may become obvious by the end of flowering and seed set. Resins occasionally secrete through pores in the membrane of gland heads. Usually secretion occurs many weeks after the stalked glands appear. The glands seem to empty their contents, leaving hollow spaces (vacuoles) in the stalk and head cells. After secretion, the glands cease to function and begin to degenerate. Gland heads, stalks, and trichomes become clumped together, and the whole flowering surface becomes a sticky mass. For reasons we'll go into later, this is not necessarily desirable. (see sections 20,21.)

Small quantities of cannabinoids are present in the internal tissues of the plant. The bulk is found in small single cells (non-articulated laticifers) that elongate to form small, individual resin canals. The resin canals ramify the developing shoots, and penetrate the plant's conducting tissue (phloem). Minute clumps of resin found in the phloem are probably deposited by these resin canals. Other plant cells contain insignificant amounts of cannabinoids and probably a good 90 percent of the cannabinoids are localised in the resin glands.

Cannabinoid synthesis seems to occur primarily in the head and apex of the stalk cells of the resin glands (26). Lacticifers and possibly other plant cells probably contribute by synthesising the simpler molecules that will eventually make up the cannabinoids. Biosynthesis (the way the plant makes the molecules) of the cannabinoids is believed to follow a scheme originally outlined by A.R. Todd in his paper "Hashish," published in 1946 (see Figure 19). In the 1960s the pathway was worked out by Raphal Mechoulam, and confirmed in 1975 by Dr. Shimomura and his associates.

{Figure 19. Possible biosynthesis of cannabinoids.}

Notice that all the cannabinoids are their acid forms with a (COOH) carboxyl group at C-2 in the aromatic ring. This group may also appear at C-4 and the compounds are called, for example, THC acid "A" and THC acid "B", respectively. The position of the carboxyl group does not affect the potency, but, in fact, in their acid forms the cannabinoids are not psychoactive. In fresh plant material, cannabinoids are almost entirely inn their acid forms. The normal procedure of curing and smoking the grass (heat) removes the carboxyl group, forming the gas CO2 and the psychoactive neutral cannabinoids. Removing the CO2 in important only if you plan to eat the marijuana. It is then necessary to apply heat (baking in brownies, for example) for the cannabinoids to become psychoactive. Ten minutes of baking marijuana at 200F is enough to convert the THC acids to neutral THC.

The formation of CBG acid, from which all the other cannabinoids are formed, is initially made from much simpler compounds containing terpene units. The example here is olivetolic acid condensing with a terpene moiety called geranyl pyrophosphate. It is not known whether these are the actual or only precursors to CBG in the living plant.

Terpenes and related substances are quite light and some of them can be extracted by steam distillation to yield the "essential oil" of the plant (from essence - giving the flavour, aroma, character). Over 30 of these related oily substances have been identified from Cannabis (143). On exposure to light and air, some of the polymerise, forming resins and tars.

The cannabinoids are odourless; most of the sweet, distinctive, pleasant "minty" fragrance and taste of fresh marijuana comes from only five substances which make up only 5 to 10 percent of the essential oils: the mono- and sesqui-terpenes alpha- and beta-pinene, limonene, myrcene, and beta-phalandrene (144). These oily substances are volatile and enter the air quickly, dissipating with time. Subsequently, the marijuana loses much of its sweetness and minty bouquet.

The essential oils constitute about .1 to .3 percent of the dry weight of a fresh marijuana sample, or on the order of 10 percent of the weight of the cannabinoids. Essential oils are found within the heads of the resin glands and make up about 10 to 20 percent of their contents in fresh material (146). They have also been detected in the resin canals (laticifers) (31).

Different samples of Cannabis have essential oils of different composition. This is not surprising given the variability of the plant. Since substances found in the essential oils are, or are related to, substances that are the precursors of the cannabinoids, there is some chance that a relationship exists between a particular bouquet and cannabinoids content. No such relationship is yet known, but it has only been studied superficially. When connoisseurs sample the bouquet of a grass sample, they are basically determining whether it is fresh. Fresh grass mean fresh cannabinoids and less of these are likely to have been degraded to non-psychoactive products.

2.4 Production of Cannabinoids by Cannabis

Why Cannabis produces cannabinoids and resins is a question probably every grower has wondered about. Supposedly, if you know, you could stimulate an environmental factor to increase cannabinoids production. Unfortunately, it does not follow that increasing a particular selective pressure will affect a plant's (phenotype) cannabinoids production. However, over a period of generations, it is possible that environmental manipulations can increase the overall cannabinoids concentrations in a population of plants. But even this procedure would work slowly compared to direct breeding by the farmer.

From the microstructure of the resin glands and the complexity of the resin, it is apparent that Cannabis invests considerable energy in making and storing the cannabinoids. Obviously, the cannabinoids are not a simple by-product or excretory product. No doubt the cannabinoids and resins serve the plant in many ways, but probably they have more to do with biotic factors (other living things) rather than abiotic factors (non-living environment such as sunlight, moisture, etc.).

The cannabinoids, resins, and related substances make up a complex and biologically highly active group of chemicals, a virtual chemical arsenal from which the plant draws its means for dealing with other organisms. This would apply especially to herbivores, pathogens, and competing plants. In the case of humans, the cannabinoids are an attractant. Some possible advantages to the plant are listed below, but no direct studies have been done on this question. Indeed, it is surprising that botanists have shown so little interest in this question; they have even gone out of their way to state their lack of interest.

Possible Advantages of Cannabinoid Production

1. Obviously the cannabinoids are psychoactive and physiologically active in many animals. This may dissuade plant-eating animals from eating the plant, especially the reproductive parts. Many birds enjoy Cannabis seeds. But in nature, birds will not bother young seeds, probably because they are encased in the cannabinoids-rich bracts. In wild or weedy plants, when the seed is mature it "shells out" and falls to the ground. Birds will eat the naked seeds. However, matured seeds are quite hard. Many will not be cracked and eventually will be dropped elsewhere, helping the plant to propagate. Bees and other insects are attracted to the pollen. The cannabinoids and resins may deter insects from feeding on pollen and developing seeds. Resin glands reach their largest size on the anthers (which hold pollen) and bracts (which contain the seed). {See plates 6, 7, 10 and 11.} 2. Terpenoid and phenolic resins are known to inhibit germination of some seeds. Cannabis resins may help Cannabis seedlings compete with other seedlings by inhibiting their germination. 3. Many of the cannabinoids (CBD, CBG, CBC and their acids) are highly active antibiotics against a wide range of bacteria (almost all are gram +) (36,130,184). Crude resin extracts have been shown to be nematocidal (36). (However, fungicidal activity is low.)

Most of the explanations you've probably heard for resin production from both lore and scientists have to do with physical factors such as sunlight, heat, and dryness. Presumably the resin coats the plant, protecting it from drying out under physical extremes. These explanations make little sense in light of the resins' chemistry.

The physical qualities of the glands and resins probably aid the plant in some ways. The sticky nature of resin may help pollen grains to adhere to the flowering mass and stigmas, or simply make the plant parts less palatable. And gland heads do absorb and reflect considerable sunlight, and so possibly protect the developing seed. For instance, gland heads are at first colourless (i.e., they absorb ultraviolet light). This screening of ultraviolet light, a known mutagen, may lower possible deleterious mutations. But physical properties seem to be secondary to the resins' chemical properties as functional compounds to the plant.

2.5 Cannabis Chemotypes

All Cannabis plants produce some cannabinoids. Each strain produces characteristic amounts of particular cannabinoids. Strains differ in the total amounts they contain. Usually they average about three percent cannabinoids to dry weight, but concentrations range from about one to 12 percent cannabinoids in a cleaned (seeds and stems removed), dried bud. Strains also differ in which cannabinoids they produce. Based on which cannabinoids, Cannabis strains can be divided into five broad chemical groups.((Chemical classification based on work by Small et al (51))) The general trend is for plants to have either THC or CBD as the main cannabinoid.

Type I

Strains are high in THC and low in CBD. This type represents some of the finest marijuana strains. They usually originate from tropical zones below 30 degrees latitude, which in the north runs through Houston and New Orleans to Morocco, North India, and Shanghai, and in the south through Rio de Janeiro, South Africa, and Australia. Most of the high-quality marijuana from Mexico, Jamaica, and Colombia sols in this country is this type; most of you will grow this type. As with all five chemical types, type I comes in different sizes and shapes. Most common are plant about 10 to 12 feet tall (outdoors), quite bushy, with branches that grow outward to form the plant into a cone (Christmas tree shape). Other tall varieties (to 18 feet) have branches that grow upward (poplar-tree shaped - some Mexican, Southeast and Central Asian varieties). A less common short variety (up to eight feet) develops several main stems and the plants appear to sprawl (Mexico, India).

Type II

This is an intermediate group, with high CBD and moderate to high THC. They usually originate from countries bordering 30 degrees latitude, such as Morocco, Afghanistan and Pakistan. In this country, this type of grass usually comes from Afghani and Colombian varieties. Type II plants are quite variable in the intensity and quality of the high they produce, depending on the relative amounts of THC and CBD in the variety. Probably because of their high CBD and overall resin content, these plants are often sued to prepare hashish and other concentrated forms of marijuana. The most common varieties grow to about eight to 12 feet and assume a poplar-tree shape with long branches that grow upward from the stem base and much shorter branches toward the top. They usually come from Turkey, Greece, and Central or Southeast Asia and occasionally from Colombia and Mexico. Some varieties are shorter, about four to eight feet at maturity, and very bushy with a luxuriant covering of leaves. These usually originate from Nepal, northern India, and other parts of Central Asia as well as North Africa. Other varieties appear remarkably like short (five to seven feet) hemp plants, with straight, slender stems and small, weakly developed branches (Vietnam). A common short variety, less than four feet tall (Lebanon, N. Africa), forms a continuous dense cluster of buds along its short stem. They appear remarkably like the upper half of more common marijuana plants.

{Figure 20. Left: This Pakistani variety ("indica") reaches a height of five feet (large leaves removed). Right: Flowering top two months later.}

Type III

Plants are high in CBD and low in THC. These are often cultivated for hemp fibre or oil seed. Usually they originate from countries north of 30 degrees latitude. As marijuana they yield a low-potency grass and are considered non-drug varieties. If you choose your seeds from potent grass, it will not be this type. An example of these plants are Midwestern weedy hemps which are often collected and sold for low-grade domestic grass. The high CBD content can make you feel drowsy with a mild headache long before you feel high. These plants are very diverse morphologically even when categorised by cultivated types. Hemp plants are usually tell (eight to 20 feet) with an emphasis on stem development and minimal branching. Starting from the base, long, even internodes (stem portion from one set of leaves to the next pair) and opposite phyllotaxy (see 3.2) cover a good portion of the stem. Some varieties form long, sparse branches only on the upper portion of the stem (many Midwest weeds). Other varieties (Kentucky hemp) are the familiar Christmas-tree shape.

Seed varieties are usually short (two to eight feet) and very bushy. Branches on some are short, grow outward and are all of approximately the same length, giving the plant a cylindrical shape. Some of the shorter (two to three feet) seed varieties have undeveloped branches, and almost all of the seeds collect in a massive cluster along the top portion of the stalk. Seed plants are often the most unusual-appearing of Cannabis plants, and you won't find them in the United States.

As expected, the figures for average THC in Midwestern weeds are quite low. this is consistent with their reputation for low potency. But the range of THC goes up to 2.37 percent in the Illinois study. This is comparable with some of the higher-quality imported marijuana and is consistent with some people's claims that Midwestern weeds provided them with great highs.

Type IV

Varieties that produce propyl cannabinoids in significant amounts (over five percent of total cannabinoids) form a fourth group from both type I and II plants. Testing for the propyl cannabinoids has been limited and most reports do not include them. They have been found in plants from South Africa, Nigeria, Afghanistan, India, Pakistan, and Nepal with THCV as high as 53.69 percent of total cannabinoids (136). They usually have moderate to high levels of both THC and CBD and hence have a complex cannabinoid chemistry. Type IV plants represent some of the world's more exotic marijuana varieties.

A fifth type, based on the production of CBGM, which is not psychoactive, is found in northeastern Asia, including Japan, Korea and China. This type is not relevant to us and will not be mentioned again.

There are many different techniques for sampling, extraction, and estimation of cannabinoids in plant material. To minimise differences among research groups, the above data (except for Midwestern weedy hemps) are taken from studies at the University of Mississippi at Oxford (66,119,136).

Unfortunately, some of the best Colombian, Mexican and Thai varieties are not included in the data. Many of these have not been tested until recently, and the figures are not yet published. Under the system for testing at the University of Mississippi, the highest THC variety reached six to eight percent THC in a bud. These seeds originated from Mexico.

{See Table 01 to 10.}

These five chemical types are not distinct entities; that is, each type contains several quite different-appearing varieties. Actually, varieties of different types may look more similar than varieties from the same type. But the ability to produce characteristic amounts of particular cannabinoids is genetically based. This means the each type contains certain genes and gene combinations in common, and in biological terms, the plants are called chemical genotypes.

These types may be from virtually any country simply because of the plant's past and ongoing history of movement. the first three can be found in most countries where Cannabis is heavily cultivated, although marijuana plants (types I, II, IV) usually originate from lower latitudes nearer the equator. This may be simply explained in terms of cultural practices. Marijuana traditionally has been cultivated in southerly cultures such as India, Southeast and Central Asia, Africa; and in the West in Mexico, Colombia, Jamaica, and Central American countries. On the other hand, useful characteristics must exist before cultures can put them to use after selection. And the characteristic (drug or fibre) must maintain itself within the local environment (see 18.4).

Non-drug types (type III) usually originate at higher latitudes with shorter growing seasons. A definite gradation exists for non-drug to drug types, starting in temperate zones and moving toward the equator. The same gradation may be found for the appearance of propyl cannabinoids toward the equator. This doesn't mean that the quality of the grass you grow depends on whether you live in the north or south, but that over a period of years and decades, a group of plants may drift toward either the drug or the non-drug type (either rich in THC or rich in CBD).

The majority of the marijuana sold in the United States has less than one percent THC; and the bulk of this comes from Mexican and domestic sources. The highest percentages of THC in marijuana that we've seen are: Colombian (9.7), Mexican (13.2), Hawaiian (7.8), and Thai sticks (20.2; however, this is believed to be adulterated with hash oil). The percentages of THC reported vary greatly, because they depend on the particular method of sampling and estimation used.

Five samples of Colombian Golds, bought in New York City and San Francisco for from $30 to $50 (1976) an ounce, averaged 2.59 percent THC and 1.27 percent CBN. The CBN represents an average of about one-third of the THC originally present in the fresh plant by the time it reaches American streets. This is one advantage that homegrowers have, since their marijuana is fresh. In fresh plant material, less than 10 percent of the THC will have been converted to CBN, as long as the material is properly harvested, cured, and stored.

By the time hashish reaches the American market, THC content is usually at the low end of the ranges given here, usually between 1.5 and 4 percent THC. The darker outer layer of hashish is caused by deterioration. The inner part will contain the highest concentration of THC.

The average range for hash oil and red oil is 12 to 25 percent when it is fresh. It is not uncommon for illicit hash oil to have more than 60 percent THC. However, light, as well as air, very rapidly decomposes THC in the oil form (see the section on "Storage" in section 21). You can't tell whether the oil will be wondrous or worthless unless you smoke it.

The preparations listed in Tables 9 and 10 are relatively fresh compared to hashish on the American market. Total cannabinoids make up roughly 25 to 35 percent by weight of hashish and resin preparations. Note that the data in these tables are relative concentrations.

Table 10 -Relative Percentages of Major Cannabinoids in Hashish from Nepal Percentage(a) of THC HASHISH THC CBD CBN THCV CBDV CBV LOST(b) Sample 1 11.5 35.9 22.1 5.7 12.5 12.3 66 Sample 2 3.4 41.1 24.8 3 11.9 15.8 88 Sample 3 5.5 41.2 30.3 2.3 9.1 11.6 85 a Each row in these columns sums to 100% b Percentage of original THC lost as CBN

The very high figures for CBN in hashish indicate that much of the THC is converted to CBN because of processing and aging. During hashmaking many of the gland heads are broken and the THC is exposed to light and air. The figures in these tables are typical of what to expect for relative concentrations of THC in hashish on the American market. Actual concentrations are roughly one-fourth to one-third of these figures.

Obviously, THC percentages for hashish and tinctures are not that high compared to fine marijuana. Hashish in the United States seldom lives up to its reputation. The best buy in terms of the amount of THC for the money is hash oil when it is high quality and fresh. More often a fine homegrown sinsemilla or sometimes a lightly seeded Colombian is the best investment. (Of course, the best value is always what

you grow yourself.)

Chapter Three
BEFORE CULTIVATION BEGINS

3.2 Choosing Seeds

Popular Market names of different grades of grass, such as Colombian commercial and Mexican regular, are familiar to growers, but each grade actually may encompass many different varieties. For example, there are Colombian Golds that are similar in most respects, but some varieties grow no taller than six feet. The more common types grow 12 to 15 feet under the same conditions. Some Oaxacan Cannabis forms several strong upright branches by maturity, and at a glance may seem to have several stems, yet more often, Oaxacan is conical-shaped and grows about 12 feet.

Most of the fine marijuana sold in this country comes from type I plants with THC as the predominant cannabinoid. Type II plants are less common. You might recognise type II plants by the high. The grass takes longer before its effects are felt, but the high lasts much longer than with other marijuana. Type IV plants are the least common; this marijuana seldom reaches the general American market. This type will get you high after only a few tokes. Type III plants are considered non-drug varieties because they are predominantly CBD with little THC. The effects of CBD are not felt unless it is accompanied by a sizeable concentration of THC, such as in type II plants. However, a lot of marijuana from these plants is sold in the United States. Some Mexican and Jamaican regular and much of the low-grade domestic is harvested from type III plants.

You may not be able to tell what type plant you're smoking, but you can tell what you like. Seeds from high-quality marijuana will grow into high-quality marijuana plants. If you like the grass you're smoking, you'll like the grass you grow.

The name of your grass has little to do with potency and may have originated in the mind of some enterprising dealer. Always choose your seeds from what you consider to be the best grass. Don't be swayed by exotic names. If you are not familiar with grass of connoisseur quality, ask someone whose experience you respect for seeds. Smokers tend to save seeds from exceptional grass even if they never plan to plant them.

The origin of your grass even if you knew it for certain, has little to do with wether it will be dynamite or worthless smoke. In both India(45) and Brazil, hemp is grown which is worthless for marijuana. Likewise, extremely potent marijuana plants grow which are useless for hemp fibre. These plants are sometimes found growing in adjacent fields. Most of the fine-quality marijuana varieties develop in those countries nearer to the equator. How much this had to do with environmental conditions or cultural practices is unknown. In either case, marijuana traffic has been so heavy that fine varieties now grow all over the world. For example, in the United States thousands of people now grow varieties from Mexico. These fine varieties originated in Asia and Africa, and many were brought to Mexican farmers by American dealers during the 1960s. As more farmers grew these new varieties, the quality of Mexican grass imported to the United States improved. Already people are speaking of varieties such as Maui Wowie and Kona Gold.

The colour of the grass does not determine its potency. Marijuana plants are almost always green, the upper surface of the leaves a dark, luxuriant green, and the undersurface a lighter, paler green. Some varieties develop reds and purples along stems and leaf petioles. Occasionally, even the leaves turn red/purple during the last stages of growth (plate 6). Grasses termed "Red" more often get their colour from the stigmas of the female flowers, which can turn from white to a rust or red colour, giving the marijuana buds a distinct reddish tinge. The golds and browns of commercial grasses are determined by the condition of the plant when it was harvested - whether it was healthy (green) or dying (autumn colours). How the plants are harvested, cured, and stored also has a serious effect on colour. Commercial grasses from Colombia, Mexico, and Jamaica are often poorly cured and packed. Too much

moisture is left in the grass, encouraging microbial decomposition; with warm temperatures, whatever green was left disappears, leaving the more familiar browns and golds. Bythe time they reach the United States, commercial grasses lose about five to 20 percent of their weight in water loss and often smell mouldy or musty.

Colour also depends on origin - varieties adapted to tropical or high-altitude areas have less chlorophyll and more accessory pigments, giving the plant their autumn colours (accessory pigments protect the plant from excessive sunlight). Varieties adapted to northern climates, where sunlight is less intense, have more chlorophyll and less accessory pigments. The dying leaves often turn light yellow, grey, or rust. Variations in pigment concentrations are also influenced by local light particularly the soil conditions under which the plants are grown.

The taste of the smoke - its flavour, aroma, and harshness - also depends more on when the marijuana was harvested and how it was handled after it was grown than on the variety or environmental influences.

You can detect subtle differences in the overall bouquet between freshly picked varieties. The environment probably influences bouquet too, but with most commercial grass the harvesting/storing procedures for outweigh these other, more subtle factors. A musty, harsh-smoking Colombian marijuana can give the mildest, sweetest, homegrown smoke when properly prepared. Don't be influenced by the marijuana's superficial characteristics. Choose seeds from the most potent grass.

Grasses of comparable potency can yield plants of different potencies. This is because fine sinsemilla (homegrown, Hawaiians, Thai weeds, and some Mexicans) are carefully tended and harvested at about peak potency. They are also cured and packed well; so they are fresh when they are distributed in the American market. When you smoke them you are experiencing the at about its peak potency. The seeds you plant from this grass will produce plants, at best, of about equal potency. Sometimes they are slightly less simply because of differences in growing conditions. Colombian grasses are not usually harvested at their peak potency. A significant amount (20 percent and up) of the active cannabinoids (THC,CBD) are converted to much less active cannabinoids (CBN,CBS) or inactive ingredients (polymers-tars, resins, oils, etc.). This is also true of many Mexican and Jamaican grasses that are heavily seeded and poorly handled. Homegrown from this grass can produce plants of higher potency than the original, simply because the homegrown is fresh, and is harvested and cured well so that the THC content is at its peak.

When choosing seeds you might consider the following Broad Generalisations. Mexican, Jamaican (if you can find goof Jamaican anymore), and homegrowns, including Hawaiians, often develop quickly and have a better chance of fully maturing in the shorter growing seasons over most of the north and central states. Colombian, African, and Southeast Asian varieties, such as Vietnam and Thai sticks (from Thailand and Japan), more often need a longer season to fully develop/ Under natural conditions they seldom flower in the short growing season that covers the northern United States.

For indoor growers, the growing season is all year; so it doesn't matter if plants need longer to develop. Mexican and Jamaican plants usually reach full potency in about six months. Colombian and Southeast Asian varieties may need eight or nine months until they reach their maximum THC or general resin content under indoor conditions.

The grass you choose should have a good stock of mature seeds. Thai weed and fine homegrowns (sinsemillas, which are by definition female flowers buds without seeds) may have no seeds at all but more often have a few viable seeds. Most Colombian and Mexican grasses contain between one and two thousand seeds per ounce bag or lid of grass. This may sound like an exaggerated figure, but it's not. Look at the photos in Figure 21 showing the yield from some Michoacan buds. The yield is 40 percent grass (1.22 grams, about three joints), 50 percent seeds (1.56 grams or 120 seeds), and 10 percent stems (0.3 grams).

Relative to smoking material, seeds are heavy. Colombian grasses average about 50 percent seeds by weight. A film canister holds about 1,200 Colombian seeds. {Figure 21, Seeded buds often contain more weight in seeds than grass}

Depending on the variety, healthy mature seeds (which are botanically achene nots) vary in size between 1/12 and 1/4 inches in length. From any variety, choose seeds that are plump and well-formed with well-developed colour. Seed colours range from a buff through a dark brown, and from light grey to almost black colours. Often seeds are mottled with brown or black spots, bars, or lines on a lighter field {plate 11}. Green or whitish seeds are usually immature and will germinate feebly if at all. Fresh seeds have a waxy glimmer and a hard, intact shell. Shiny, very dark brown or black seeds often mean the contents are fermented and the embryo is dead. Fermented seeds crush easily with finger pressure and are hollow or dust inside. Seeds that are bruised or crushed are also not viable. This happens to some seeds when grass is compressed or bricked.

Fresh, fully matured Cannabis seeds have a high rate of germination; 90 percent or better is typical. It is sometimes helpful to have an idea of how many seeds to expect to germinate. You can tell simply by placing a sample number between wet paper towels which are kept moist. Most of the seeds that germinate do so within a few days of each other. After a week or two, count how many of the original seeds germinated. This gives you a rough idea of what to expect from the seeds when planted.

The viability of seeds gradually declines with time; left in the ground, only 40 percent may germinate next season. Seeds are n ideal pray for many fungi, which are responsible for most of their deterioration. In a warm (70F or over) and humid atmosphere, fungi rapidly destroy seeds. If kept cool and dry in an airtight container, seeds stored in this way and left in the buds also maintain high viability for over two years.

3.3 CANNABIS LIFE CYCLE

Marijuana plants may belong to any one of a number of varieties which follow somewhat different growth patterns. The following outline describes the more common form of growth. Differences between varieties can be thought of as variations on this standard theme.

Cannabis is an annual plant. A single season completes a generation, leaving all hope for the future to the seeds. The normal life cycle follows the general pattern described below.

Germination

With winter past, the moisture and warmth of spring stir activity in the embryo. Water is absorbed and the embryo's tissues swell and grow, splitting the seed along its suture. The radical or embryonic root appears first. Once clear of the seed, the root directs growth downward in response to gravity. Meanwhile, the seed is being lifted upward by growing cells which form the seedling's stem. Now anchored by the roots, and receiving water and nutrients, the embryonic leaves (cotyledons) unfold. They are a pair of small, somewhat oval, simple leaves, now green with chlorophyll to absorb the life-giving light. Germination is complete. The embryo has been reborn and is now a seedling living on the food it produces through photosynthesis. The process of germination is usually completed in three to 10 days.

Seedling

The second pair of leaves begins the seedling stage. They are set opposite each other and usually have a single blade. They differ from the embryonic leaves by their larger size, spearhead shape, and serrated margins. With the next pair of leaves that appears, usually each leaf has three blades and is larger still. A basic pattern has been set. Each new set of leaves will be larger, with a higher number of blades per leaf until, depending on variety, they reach their maximum number, often nine or 11. The seedling stage is completed within four to six weeks.

Vegetative Growth

This is the period of maximum growth. The plant can grow no faster than the rate that its leaves can produce energy for new growth. Each day more leaf tissue is created, increasing the overall capacity for growth. With excellent growing conditions, Cannabis has been known to grow six inches a day, although the rate is more commonly one to two inches. The number of blades on each leaf begins to decline during the middle of the vegetative stage. Then the arrangement of the leaves on the stem (phyllotaxy) changes

from the usual opposite to alternate. The internodes (stem space from one pair of leaves to the next, which had been increasing in length) begin to decrease, and the growth appears to be thicker. Branches which appeared in the axils of each set of leaves grow and shape the plant to its characteristic form. The vegetative stage is usually completed in the third to fifth months of growth.

Preflowering

This is a quiescent period of one to two weeks during which growth slows considerably. The plant is beginning a new program of growth as encoded in its genes. The old system is turned off and the new program beings with the appearance of the first flowers.

Flowering

Cannabis is dioecious: each plant produces either male or female flowers, and is considered either a male or female plant. Male plants usually start to flowers about one month before the female; however, there is sufficient overlap to ensure pollination. First the upper internodes elongate; in a few days the male flowers appear. The male flowers are quite small, about 1/4 inch, and are pale green, yellow, or red/purple. They develop in dense, drooping clusters (cymes) capable of releasing clouds of pollen dust. Once pollen falls, males lose vigour and soon die.

The female flowers consists of two small (1/4 to 1/2 inch long), fuzzy white stigmas raised in a V sign and attached at the base to an ovule which is contained in a tiny green pod. The pod is formed from modified leaves (bracts and bracteoles) which envelop the developing seed. The female flowers develop tightly together to form dense clusters (racemes) or buds, cones, or colas (in this book, buds). The bloom continues until pollen reaches the flowers, fertilising them and beginning the formation of seeds. Flowering usually lasts about one or two months, but may continue longer when the plants are not pollinated and there is no killing frost.

Seed Set

A fertilised female flower develops a single seed wrapped in the bracts. In thick clusters, they form the seed-filled buds that make up most fine imported marijuana. After pollination, mature, viable seeds take from 10 days to five weeks to develop. When seeds are desired, the plant is harvested when enough seeds have reached full colour. For a fully-seeded plant this often takes place when the plant has stopped growth and is, in fact, dying. During flowering and seed set, various colours may appear. All the plant's energy goes to reproduction and the continuance of its kind. Minerals and nutrients flow from the leaves to the seeds, and the chlorophylls that give the plant its green colour disintegrate. The golds, browns, and reds which appear are from accessory pigments that formerly had been masked by chlorophyll.

Figure 30 THC potency through various growth stages in the male and female plant

About Plants Generally

Plants use a fundamentally different "life strategy" from animals. Animals are more or less self-contained units that grow and develop to predetermined forms. They use movement and choice of behaviour to deal with the changing environments. Plants are organised more as open systems - the simple physical characteristics of the environment, such as sunlight, water, and temperature, directly control their growth, form, and life cycles. Once the seed sprouts, the plant is rooted in place and time. Since growth is regulated by the environment, development is on accordance with the plant's immediate surroundings. When a balance is struck, the strategy is a success and life flourishes.

Behaviour of a plant is not a matter of choice; it is a fixed response. On a visible level the response more often than not is growth, either a new form of growth, or specialised growth. By directly responding, plant in effect "know," for example, when to sprout, flower, or drop leaves to prepare for winter.

Everyone has seen how a plant turns toward light or can bend upward if it its stem is bent down. The

plant turns by growing cells of different length on opposite sides of the stem. This effect turns or right the plant. The stimulus in the first case is light, in the second gravity, but essentially the plant responds by specialised growth. It is the same with almost all facets of a plant's live - growth is modified and controlled by the immediate environment. The influence of light, wind, rainfall, etc., interacts with the plant (its genetic make-up or genotype) to produce the individual plant (phenotype).

The life cycle of Cannabis is usually complete in four to nine months. The actual time depends on variety, but it is regulated by local growing conditions, specifically the photoperiod (length of day vs night). Cannabis is a long-night (or short-day) plant. When exposed to a period of two weeks of long nights - that is, 13 or more hours of continuous darkness each night - the plants respond by flowering. This has important implications, for it allows the grower to control the life cycle of the plant and adapt it to local growing conditions or unique situations. Since you can control flowering, you control maturation and, hence, the age of the plants at harvest.

3.4 PHOTOPERIOD AND FLOWERING

For the marijuana grower the most important plant/environment interaction to understand is the influence of the photoperiod. The photoperiod is the daily number of hours of day (light) vs. night (dark). In nature, long nights signal the plant that winter is coming and that it is time to flowers and produce seeds. As long as the day-length is long, the plants continue vegetative growth. If female flowers do appear, there will only be a few. These flowers will not form the characteristic large clusters or buds. If the days are too short, the plants flowers too soon, and remain small and underdeveloped.

The plant "senses" the longer nights by a direct interaction with light. A flowering hormone is present during all stages of growth. This hormone is sensitive to light and is rendered inactive by even low levels of light. When the dark periods are long enough, the hormones increase to a critical level that triggers the reproductive cycle. Vegetative growth ends and flowering begins.

The natural photoperiod changes with the passing of seasons. In the Northern Hemisphere, the length of daylight is longest on June 21. Day-length gradually decreases until it reaches its shortest duration on December 22. The duration of daylight then begins to increase until the cycle is completed the following June 21. Because the Earth is tilted on its axis to the sun, day-length also depends on position (or latitude) on Earth. As one moves closer to the equator, changes in the photoperiod are less drastic over the course of a year. At the equator (0 degrees altitude) day length lasts about 12.5 hours on June 21 and 11.5 hours on December 22. In Maine (about 45 degrees north), day-length varies between about 16 and nine hours. Near the Arctic Circe on June 21 there is no night. On December 22 the whole day is dark. The longer day-length toward the north prevents marijuana from flowering until later in the season. Over most of the northern half of the country, flowering is often so late that development cannot be completed before the onset of cold weather and heavy frosts.

The actual length of day largely depends on local conditions, such as cloud cover, altitude, and terrain. On a flat Midwest plain, the effective length of day is about 30 minutes longer than sunrise to sunset. In practical terms, it is little help to calculate the photoperiod, but it is important to realise how it affects the plants and how you can use it to you advantage.

Cannabis generally needs about two weeks of successive long nights before the first flowers appear. The photoperiod necessary for flowering will vary slight with (1) the variety, (2) the age of the plant, (3) its sex, and (4) growing conditions.

1. Cannabis varieties originating from more northerly climes (short growing seasons) react to as little as nine hours of night. Most of these are hemp and seed varieties that are acclimated to short growing seasons, such as the weedy hemps of Minnesota or southern Canada. Varieties from more southerly latitudes need longer nights with 11 to 13 hours of darkness. Since most marijuana plants are acclimated to southerly latitudes, they need the longer nights to flower. To be on the safe side, if you give Cannabis plant dark periods of 13 or more hours, each night for two weeks, this should be enough to trigger flowering. 2. The older a plant (the more physiologically developed), the quicker it responds to long nights. Plants five or six months old

sometimes form visible flowers after only four long nights. Young marijuana plants (a month or so of age) can take up to four weeks to respond to long nights of 16 hours. 3. Both male and female Cannabis are long-night plants. Both will flower when given about two weeks of long nights. The male plant, however, will often flower fully under very long days (18 hours) and short nights (six hours). Males often flowers at about the same time they would if they were growing in their original environment. For most marijuana plants this occurs during the third to fifth month. 4. Growing conditions affect flowering in many ways (see Chapter 12). Cool temperatures (about 50F) slow down the flowering response. Cool temperatures or generally poor growing conditions affect flowering indirectly. Flower development is slower, and more time is needed to reach full bloom. Under adverse conditions, female buds will not develop to full size.

Applications of Photoperiod

The photoperiod is used to manipulate the plants in two basic ways:

1. By giving long dark periods, you can force plants to flower. 2. By preventing long nights, using artificial light to interrupt the dark period, you can force the plants to continue vegetative growth.

Outdoors

Most marijuana plants cultivated in the United States begin to flower by late August to early October and the plants are harvested from October to November. For farmers in the South, parts of the Midwest, and West Coast, this presents no problem and no special techniques are needed for normal flowering.

In much of the North and high-altitude areas, many varieties will not have time to complete flowering before fall frosts. To force the plants to flower earlier, give them longer night periods. If the plants are in containers, you can simply move them into a darkened area each evening. Plants growing in the ground can be covered with an opaque tarpaulin, black sheet plastic, or double or triple-layers black plastic trash bags. Take advantage of any natural shading because direct sunlight is difficult to screen completely. For instance, if the plants are naturally shaded in the morning hours, cover the plants each evening or night. The next morning you uncover the plants at about eight to nine o'clock. Continue the treatment each day until all the plants are showing flowers. This usually takes two weeks at most, is the plants are well developed (about four months old). For this reason, where the season starts late, it is best to start the plants indoors or in cold frames and transplant outdoors when the weather is mild. This in effect lengthens the local growing season and gives the plants another month or two to develop. By the end of August the plants are physiologically ready to flower; they sometimes do with no manipulation of the photoperiod. More often female plants show a few flowers, but the day-length prevents rapid development to large clusters. The plants seem in limbo - caught between vegetative growth and flowering. The natural day-length at this time of year will not be long enough to reverse the process, so you can discontinue the treatment when you see that the new growth is predominantly flowers.

In areas where frosts are likely to occur by early October, long-night treatments may be the only way you can harvest good-sized flower clusters. These clusters, or buds, are the most potent plant parts and make up the desired harvest. Forcing the plants to flowers early also means development while the weather is warm and the sun is shining strongly. The flower buds will form much faster, larger and reach their peak potency. A good time to start the treatments is early to middle August. This allows the plants at least four weeks of flowering while the weather is mild.

Another reason you may want to do this is to synchronise the life cycle of the plants with the indigenous vegetation. In the northeast and central states, the growing season ends quite early and much of the local vegetation dies back and changes colour. Any marijuana plants stick out like green thumbs, and the crop may get ripped off or busted. Plants treated with long nights during late July will be ready to harvest in September.

Outdoors, growers should always plant several varieties, because some may naturally flower early, even in the northern-most parts of the country. These early-maturing varieties usually come from Mexican, Central Asian, and homegrown sources. By planting several varieties, many of you will be able to find or

develop an early-maturing variety after a season or two. This, of course, is an important point, because it eliminates the need for long-night treatments.

Preventing Flowers

Manipulation of the photoperiod can also prevent the plants from flowering until a desired time. For example, in Hawaii the weather is mild enough to grow winter crops. The normal summer crop is harvested anytime from September to mid-November. The winter crop is generally planted from October to December. Because the winter days are so short, the plants flower almost immediately, usually within two month. The plants are harvested in their third or fourth month and yield about 1/4 the yield of summer plants. A large Hawaiian female can yield a pound of buds. Most of the plant's overall size is reached while it is vegetatively growing. By interrupting the night period with light, you can keep these plants vegetatively growing for another month, yielding plants of about twice the size.

The amount of light needed to prevent flowering is quite small (about .03 foot candles95 - on a clear night the full moon is about .01 foot candles). However, each plant mist be illuminated fully, with the light shining over the whole plant. This might be accomplished with either electric light or a strong flashlight. The easiest way is to string incandescent bulbs, keeping them on a timer. The lights need be turned on for only a flash at any time during the night period, from about 9:00 pm to about 3:00 am. The interrupts the long night period to less then nine hours. Start these night treatments each night or two, until you want the plants to flower.

Indoors

Natural Light

Indoors, the growing season lasts all year. The night period is much easier to control. Sometimes people grow plants in their windows for more than a year without any female flowers ever forming. This is because household lamps are turned on sometime at night, illuminating the plants. Under natural light exclusively, indoor plants flower at about the same time they would outdoors (sometime a bit sooner because it is warmer indoors or the plants may be shaded). When plants are well developed and you want them to flower, make sure that no household lamps or nearby street lamps are shining on them. During late fall and winter, the natural day-length is short enough for the plants to flower naturally, if you simply keep off any lights at night that are in the same room as the plants. If you must use light, use the lowest wattage possible, such as a six-watt bulb. (The hormone is also least sensitive to blue light.) Shield the light away from the plants. Or shield the plants from any household light with aluminium foil curtains. Once the flowers are forming clusters, you can discontinue the dark treatments, especially if it is more convenient. However, if it is too soon (when you see only a few random flowers), household lights can reverse the process.

By using natural light, you can grow indoor crops all year. The winter light is weak and the days are short, so it is best to use artificial lights to supplement daylight, as well as to extend the photoperiod. The extra light will increase the growth rate of the plants and hence size and yield. You should allow winter crops to flower during late January or February, using the natural photoperiod to trigger flowering. If you wait until spring, the natural light period will be too long and may prevent flowering.

Artificial Lights

Under artificial light the photoperiod is, of course, any length you wish. The most popular way to grow with artificial lights is the harvest system. Start the plants under long light periods of from 16 to 18 hours daily. After the plants have reached a good size, usually between three and six months, shorten the light cycle to about 12 hours to force flowering.

To decide exactly when to force the plants to flower, let their growth be the determinant. If male plants are showing their flowers, then the females are physiologically ready to flower. Most of the plant's overall height is achieved during vegetative growth. Some varieties, of course, are smaller and grow more slowly than others. Wait until the plants are nearing the limits of the height of the garden or are at least five feet

tall. This is large enough to support good flower development and return a good yield. If you turn down the light cycle when the plants are young and small, you'll harvest much less grass because the plants simply can't sustain a large number of flowers.

Some leaf growers prefer a continuous growth system, emphasising leaf growth and a continuous supply of grass. The light cycle is set for 18 to 24 hours a day. This prevents flowering and the plants continue their rapid vegetative growth. Growing shoots and leaves are harvested as used, and plants are removed whenever they lose their vigour and growth has noticeably slowed. New plants are started in their place. In this way, there will be plants at different growth stages, some of which will be in their rapid vegetative growth stage and will be quite potent. Male plants and some females eventually will form flowers, but the females will not form large clusters. People often use this system when the lights are permanently fixed. Small plants are raised up to the lights on tables or boxes. This garden never shuts down and yields a continuous supply of grass.

3.5 INHERENT VARIATIONS IN POTENCY

The potency of a particular marijuana sample will vary because of many factors other then the variety. Many of these have to do with the natural development of the plants and their resin glands. Environmental factors do affect potency but there are large differences in any variety. These inherent factors must be explained before we can talk of factors outside the plant that affect relative potency. Strictly environmental effects are discussed in Chapter 19.

Variations in Potency Within Varieties

There are noticeable differences in THC concentrations between plants of the same variety. Differences are large enough so that you can tall (by smoking) that certain plants are better. This is no news to homegrowers, who often find a particular plant to be outstanding. Five-fold differences in THC concentration have also shown up in research. However, when you consider a whole group of plants of the same variety, they're relatively similar in cannabinoid concentrations. Type II plants are the most variable, with individual plants much higher than other in certain canninbinoids.

Variations by Plant Part

The concentration of cannabinoids depends on the plant part, or more specifically, the concentration and development of resin glands to plant part. The female flower bracts have the highest concentration of resin glands and are usually the most potent plant parts. Seeds and roots have no resin glands. These shoe no more than traces of canninbinoids. Smoke seeds will give you a headache before you can get high. If you got high on seeds, then there were probably enough bracts adhering to the seeds to get you high. {Figure 29 The highest concentration of stalked resin glands forms a cover on the female flower bracts Resin glands beneath cystolith hairs on a leaf petiole}

Here are the potencies, in descending order, of the various plant parts:

```
        1. Female flowering clusters.  In practice you don't separate
hundreds
        of tiny bracts to make a joint.  The whole flowering mass (seeds
removed),
        along with small accompanying leaves, forms the material.
        2. Male flower clusters.  These vary more in relative potency
depending on
        the strain (see "Potency by Sex," below).
        3. Growing shoots.  Before the plants flower, the vegetative shoots
(tips)
        of the main stem and branches are the most potent plant parts.
        4. Leaves (a) that accompany flowers (small);
                  (b) along branches (medium);
                  (c) along main stem (large).
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Generally, the smaller the leaf is, the more potent it can be.

5. Petioles (leaf stalks). Same order as leaves.
6. Stems. Same order as leaves. The smaller the stem (twig), the higher the possible concentration of cannabinoids. Stems over 1/16" in diameter contain only traces of cannabinoids and are not worth smoking. The small stems that bear the flowers can be quite potent.
7. Seeds and Roots. Contain only traces (less then .01 percent) and are not worth smoking or extracting.

This order is fairly consistent. The exceptions can be the small leaves that accompany male flowers, which are sometimes more potent than the flowers themselves. The growing shoots are sometimes more potent than the mature female flowers.

Samples of pollen show varying amounts of cannabinoids. Resin glands are found inside the anthers, alongside the developing pollen grains, and form two rows on opposite sides of each anther. Pollen grains are smaller than the heads of large resin glands ({see Plate 7}), and range from 21 to 69 micrometres in diameter21. A small amount of resin contaminates the pollen when glands rupture, but most of the THC in pollen samples comes from gland heads that fall with pollen when the flowers are shaken to collect it. One study, using pollen for the sample, found concentrations of up to 0.96 percent THC, more then enough to get you high79.

Potency by Position on Plant

The potency of marijuana on any plant increases toward the top of the plant, the topmost bud being the most potent. The bottommost leaves on the main stem are the least potent of the useable material. Along branches there is a less steep THC gradient increasing to the growing tip.

The ratios in Table 11 are representative of high-quality marijuana varieties. Plant no. 2 is an exception, with four percent THC in its lower leaves, a figure comparable to high-quality Colombian and Mexican buds in commercial grass.

Table 11 - Relationship of THC Content to Leaf Position (68)

Percentage of THC by weight of Leaf from Position on plant			
Plant	No. 1 (SP-5)	NO.2 (SP-5)	NO.3 (UNC-335)
Top	6.1	6.9	4.8
Middle	3	5.5	3.1
Bottom	0.8	4	1.5
Ratio (gradient)	8:4:1	1.7:1.4:1	3:2:1

Notice the large difference in the gradients of Plants no. 1 and 2, which are from the same variety (SP-5). Like almost all characteristics of these plants, considerable variation occurs even among sibling. Our experience is that generally the better the quality of the variety, the steeper the gradient: in other words, the bigger the difference between top and bottom leaves. For example, the plants given here are high-quality type I varieties. Plant no. 1 is more typical, with its steep gradient, than no.2, where the gradient is much less pronounced. Lower-quality varieties generally do not have as steep a gradient and the ratios would look more like that of Plant no. 2.

Potency by Sex

Although marijuana lore claimed the female to be the more potent, scientists disclaimed this. But there is some truth to both sides. In fine marijuana varieties, male and female leaves average about the same in cannabinoid concentrations. Either a male or a female individual may have the highest concentration in any particular case. The largest variation is in comparing the flowers. Male flowers may be comparable to the females, or they may not even get you high. It seems that the higher the quality of the grass, the

better the male flowers will be. In fine type I plants, male flowering clusters usually approach the potency of the female. In low-quality type III varieties females are usually more potent (20 to 30 percent) than the males.

Type II plants are the most variable, with large differences among individual plants. But the trend is for the females to average about 20 percent high in potency of leaves and flowers.

Table 12 - Relative Potencies of Male and Female Plants (66)

		Percentage by Weight (b) of		
COUNTRY OF ORIGIN	SEX (a)	THC	CBD (C)	TYPE PLANT
Mexico	M	3.7	0.86	I
	F	3.7	0.35	
India	M	4.3	0.12	I
	F	1.78	0.19	
Thailand	M	3.2	0.08	I
	F	3.2	0.42	
India	M	0.81	2.1	II
	F	1.3	0.89	
Pakistan	M	1.37	1.24	II
	F	0.71	1.5	
Turkey	M	0.84	2.11	II
	F	0.92	1.33	
India	M	0.15	2.2	III
	F	0.12	1.2	
Poland	M	0.04	0.97	III
	F	0.06	1.1	

a) M, male (staminate); F, female (pistillate). (b) Of flowering mass with accompanying leaves. (c) Includes CBC. _

Potency by Age

In general, the longer the life cycle of the plant, the more the concentration of cannabinoids increases, as long as the plant stays health and vigorous. Actually, it is the development of the plant, rather than chronological age, that determines this difference in potency. A plant that is more developed or more mature is generally more potent.

Because you decide when to plant and/or can control the photoperiod, you also control when the plants flowers and, hence, the overall age at maturity. A six-month-old plant will generally be better than a four-month-old plant, both of which are flowering. Plants eight months old will usually be more potent than six-month-old plants. Most indoor growers plan their gardens to be about five to eight months old at harvest. Healthy plants can be extended to about 10 months. Plants older than 10 months often develop abnormally. There is usually a decline in vigour and a loss in potency. But some growers have decorative plants several years old.

Outdoor growers more often simply allow the plants to develop according to the local growing conditions which will govern their development and flowering time. Where the growing season is short, some growers start the plants indoors and transplant when the local growing season begins. This gives the plants a longer growing season.

One reason female plants are considered more potent is because of age. Males often flower in four to five months and die, while the females may continue to a ripe old age of eight or nine months, especially when they are not pollinated.

Potency by Growth Stage

Although then general trend is for the cannabinoid concentration to increase with age, this is not a matter of the simple addition or accumulation of cannabinoids. The concentration of cannabinoids changes with the general metabolic rate of the plant, and can be related to the plant's growth pattern or life cycle. Figure 30 shows a hypothetical curve following the concentration of THC from the upper leaves and growing tips of a male and female plant.

Notice that THC increases immediately with germination and establishment of the seedling, and continues to rise until the plant enters its vegetative stage. At this point, the plant is well-formed, with a sturdy stem, and no longer looks fragile. As the plant;s rate of growth increases, there is a corresponding rise in THC that continues throughout the vegetative stage until a plateau is reached. Before the plateau is reached the arrangement of leaves on the stem (phyllotaxy) changes from opposite to alternate. The plateau is maintained until the plant's rapid growth all but stops and the plant has entered preflowering. By this time, the branches have formed the plant to its characteristic shape. Preflowering lasts about one to two weeks, during which THC concentration falls until the appearance of the first flowers.

For the male plant, preflowering ends with renewed growth. This lengthens the uppermost internodes and the first male flower buds appear. THC immediately increases with the development of the male flower clusters, and reaches its peak when most of the flowers are fully formed and a few are beginning to release pollen. After pollen release, the male normally loses vigour and THC content slowly declining until the plant is cured and stored.

Female plants reach their maximum THC when the plants are in full bloom. Full bloom is when the plant has filled out with well-formed flower clusters, but flowers are still slowly forming. Most of the stigmas will still be white and healthy.

Flowering lasts anywhere from two to 10 weeks, depending on whether the plants are pollinated or not, as well as on variety and the environment. (See Chapter 20 for details.) THC content declines as the formation of new flowers slows and the majority of the stigmas begin to brown. The only changes you may see in the plants are the maturation of the seeds and the loss of green colour in the leaves and flowers. In some cases the plant's apparent resin (its look and feel) increases during the last few weeks of life while the THC concentration is still declining.

You may feel that you should only pick marijuana when the plants are in full bloom, but this is not the case. Think of the garden as a continuous supply of grass. You can never be sure of the fate of your plants. The biggest problem with outdoor growing is that there is a good chance that the plants will be ripped off before you plan to harvest. It is much better to harvest grass during the course of a season, assuring yourself a return for your efforts. For example, during the third month of growth, you could cut back the growing tips, which should be quite potent, often more potent than Figure 30 suggests. This doesn't mean there will be less to harvest at season's end. In fact, the plant will be forced to develop its branches, possible yielding a larger plant.

Common sense tells you that it is always best to test one sample before you harvest. By taking one tip, curing and smoking, you'll know whether it's worthwhile to harvest more at that time or to wait longer. When a tip is about equal to its parents' potency, then definitely harvest more growing tips. This peak high often occurs during the middle to late rapid, vegetative-growth stage.

The reader should keep in mind that Figure 30 serves only as an example. Chronological age is not as important as the physiological age of the plant. In this graph, the life of the plants is about six months. But the life cycle depends on the particular variety and the growing conditions, which strongly influence the rate of development. (For details on how to use the graph, see Chapter 20.) The important facts that the reader should get from the graph are that the potency of the grass can decrease as well as increase during the plant's life cycle. Actual studies of the cyclic variations in potency over the course of a season have shown much more complicated rhythms, with many more peaks and valleys then here 71,74,80,86,92. Most varieties will more or less follow a growth pattern as described. Changes in the plant's development, such as phyllotaxy and growth rate, are cues to changes in THC concentration. Secondly, the growing tips of the main stem and branches can be very potent. Growers do not have to wait until flowers form to harvest top-quality smoke.

3.6 Cultivation: Indoors or Outdoors?

The basic elements of the environment (light, water, air, and soil) provide plants with their fundamental needs. These environmental factors affect the growth rates of plants, as well as their life cycles. If one factor is deficient, growth rate and vigour will wan regardless of the other three. For instance, with low light, the growth will be limited no matter how fertile and moist the soil is. In the same sense, if soil minerals are scarce, the growth rate will be limited no matter how you increase the light.

Photosynthesis

Cannabis, like all green plants, manufacturers its food through the process photosynthesis. Unlike animals, which depend on pre-formed food for survival, plants can use energy from light to form food (carbohydrates) from simple inorganic molecules absorbed from the air and soil.

Plants absorb light energy through pigments that are concentrated in the leaf cells. These pigments are also found in most of the aboveground parts of the plant. The most abundant pigment is chlorophyll, which gives the plants their green colour. The energy absorbed is stored in chemical compounds such as ATP and NADPH2. ((ATP, adenosine-triphosphate; NADPH2, nicotinamide-adenine-dinucleotide-phosphate.)) These are storage/transfer compounds that function to transfer energy and matter in the living system. ATP transfers energy that fuels the reactions for the making of carbohydrates as well as most other metabolic functions. NADPH2 transfers electrons, usually as hydrogen, for the synthesis of carbohydrates as well as other compounds.

The raw material for the synthesis of carbohydrates (CH2O)n comes from carbon dioxide (CO2) and water (H2O). Carbon dioxide is absorbed primarily from the air, but can also be absorbed from the soil and secondarily from the air.

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Photosynthesis is summarised as follow:
light energy ------- ATP + NADPH2
CO2 + H2O    ------- (CH2O)n + O2
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For more complex bio-molecules such as amino acids and proteins, the plant absorbs minerals (including nitrogen, phosphorus, and sulfur) from the soil. Carbohydrates provide food energy for the plant using processes similar to those that occur in humans. They also form the basic building blocks for plant tissues. For example, the sugar glucose (CH2O)6 is strung and bonded to farm long chains of cellulose, the most abundant organic compound on earth. About 80 percent of the structure of the plant's cells is made from cellulose.

The plant is a living thing existing in a holistic world; a myriad of factors affect its life. However, good cultivation techniques require attention to only four basic growth factors. With this accomplished, the plants will do the rest.

As grower, your strategy is to bring out the plant's natural qualities. The cannabinoids are natural to the plants. Seeds from potent marijuana grow into potent marijuana plants when they are nurtured to a full and healthy maturity.

Since most marijuana plants are adapted to tropical or semitropical climates, it is up to the grower to make the transition to local growing conditions harmonious. The requires sensible gardening techniques and, in some cases, manipulation of the photoperiod. There is no magic button to push or secret fertiliser to sue. The secret of potency lies within the embryo. The environment can and does affect potency, as it does most aspects of the plant's life. However, environmental factors are secondary to the plant's heritage (genetic potential).

Indoors vs. Outdoors

At this point the book divides into separate indoor and outdoor cultivation sections, and you may wonder whether it is better to grow the plant indoors or outdoors. Each alternative has advantages and

disadvantages. It is usually better to grow the plants outdoors if possible, because the plants can grow much larger and faster than indoors. Indoors presents space and light limitations. It is possible to grow a 15-foot bush indoors, but this is unrealistic in most home. There simply isn't enough room or light for such a large plant. Outdoor gardens return a much higher yield for the effort and expense. most indoor gardeners buy soil and may have to buy electric lights. So there is an initial investment of anywhere from $10 on up.

On the other hand, outdoor plants are more likely to be seen. Many gardens get ripped off, and busts are a constant threat. Indoor gardens are much less likely to be discovered. Gardening indoors allows the grower closer contact with the plants. The plants can be grown all year long; it is an easy matter to control their growth cycles and flowering. Probably the biggest attraction of indoor gardens is that they are beautiful to watch and easy to set up anywhere.

One popular compromise is to construct a simple greenhouse. Use plastic to either enclose part of a porch or to cover a frame built against the house.

The potency of the plants doesn't depend on whether they are grown indoors or outdoors. As long as you grow healthy plants that reach maturity and complete their life cycle, the grass can be as good as any you've ever smoked.

PART 2: INDOOR GARDENING

Chapter Four
INTRODUCTION

Marijuana adapts well to indoor conditions. You can grow it in sunny rooms or with artificial light. The factor limiting the rate of growth indoors is often the amount of light, since it is less a problem to supply the plants with plenty of water, nutrients, and air.

Natural light is free. If feasible to use, natural light eliminates the most expensive components for indoor gardeners: artificial lights and the electricity they use. Window light is the easiest way to grow plants for decorative purposes or for a small crop. On the other hand, a greenhouse, sunporch, or particularly sunny room can support larger plants than most artificial light systems. A sunny porch or roof area enclosed in sheet plastic to form a greenhouse is a simple, inexpensive way to grow pounds of grass.

Cannabis grows into a fully formed bush when it receives a minimum of five hours of sunlight a day. But you can grow good-sized plants of excellent quality with as little as two hours of daily sunlight provided windows are unobstructed by buildings or trees and allow full daylight. Windows facing south usually get the most light, followed by windows facing east and west (north-facing windows seldom get any sun). Use the location with the longest period of sunlight. The corner of a room or alcoves with windows facing in two or three directions are often very bright. Skylights are another good source of bright, unobstructed light.

Some growers supplement natural light with artificial light from incandescent or fluorescent fixtures. This is essential during the winter, when sunlight is weaker than the summer, and in spaces where the plants get little direct sunlight. Artificial lights can also be used to lengthen the natural photoperiod in order to grow plants all year.

The best time to plant using natural light is in late March or April, when the sun's intensity and the number of hours of daylight are increasing. Cleaning windows dramatically increases the amount of light, especially in cities where grime collects quickly. Paint walls adjacent to windows a flat white or cover them and the floor with aluminium foil to reflect light to the plants. Place young plants on shelves, blocks, or tables to bring them up to the light. Position the plants as close to the windows as possible. Insulate germinating plants from freezing winter drafts by stapling clear sheets of polyethylene film to the window frame.

The main problem with marijuana in windows is that it may be seen by unfriendly people. This won't be a problem at first, but when the plants grow larger, they are easily recognised. You could cover the windows with mesh curtains, rice paper, polyethylene plastic or other translucent materials to obscure the plants. A strip covering the lower part of the window may be enough to conceal the plants from outsiders.

Most of you will want the garden completely hidden. Some gardeners opt for closets, basements, attics - even under loft beds. They cover the windows if the garden is visible and grow the plants entirely with artificial light.

The amount of light you provide is what determine the garden's size - the amount of soil, number and eventual size of the plants, and the overall yield. Since light is the factor on which you base the planning of your garden, let's begin with artificial light.

{A picture of a self-contained mini-horizontal (150 or 175 watt HID) is perfect for a personal small garden.}

Chapter Five
ARTIFICIAL LIGHT[

5.2 Fixtures

Florescent light is the most effective and efficient source of artificial light readily available to the home grower. Florescent lamps are the long tubes typical of institutional lighting. They require a fixture which contains the lamp sockets and a ballast (transformer) which works on ordinary house current.

Tubes and their fixtures come in length from four inches to 12 feet. The most common and suitable are four- and eight-foot lengths. Smaller tubes emit too little light for vigorous growth; longer tubes are unwieldy and hard to find. The growing area must be large enough to accommodate one or more of these fixtures through a height of at least six feet as the plants grow. Fixtures may hold from one to six tubes and may include a reflector, used for directing more light to the plants. Some fixtures are built with holes in the reflectors in order for heat to escape. They are helpful in areas where heat builds up quickly. You can make reflectors with household materials for fixtures not equipped with reflectors. Try to get fixtures that have tubes spaced apart rather than close together. See 5.5 for further suggestions.

The tubes and their appropriate fixtures are available at several different wattage or outputs. Standard or regular output tubes use about 10 watts for each foot of their length - a four-foot tube has about 40 watts and an eight-foot tube about 80 watts.

High Output (HO) tubes use about 50 percent more watts per length than regular output tubes and emit about 40 percent more light. An eight-foot (HO) runs on 112 to 118 watts. Very High Output (VHO) or Super High Output (SHO) tubes emit about two-and-a-half times the light and use nearly three times the electricity (212 to 218 watts per eight-foot tube).

The amount of light you supply and the length of the tube determine the size of the garden. Marijuana will grow with as little as 10 watts per square foot of growing area, but the more light you give the plants, the faster and larger they will grow. We recommend at least 20 watts per square foot. The minimum-size garden contains a four-foot fixture with two 40-watt tubes, which use a total of 80 watts. Dividing total watts by 20 (watts per square foot) gives 80w divided by 20w/sq. ft=four sq.ft. (an area one by four feet). A four-tube (80 watts each) eight-foot fixture would give: 320w divided by 20w/sq. ft. = 16 sq. ft. or an area the length of the tube and about two feet wide.

VHO and HO tubes in practice don't illuminate as wide an area when the plants are young, because the light source is one or two tubes rather than a bank. Once the plants are growing well and the light system is raised higher, they will illuminate a wider area. Figure about 25 w/(ft*ft) for HO and 35 w/(ft*ft (or foot

squared)) for VHO to determine garden size. A two-tube, eight-foot VHO fixture will light an area the length of the tube and one-and-a-half feet wide.

The more light you give the plants, the faster they will grow. Near 50w/sq. ft. a point of diminishing returns is reached, and the yield of the garden is then limited by the space the plants have to grow. For maximum use of electricity and space, about 40w/sq. ft. is the highest advisable. Under this much light the growth rate is incredible. More than one grower has said they can hear the plants growing - the leaves rustle as growth changes their position. In our experience, standard-output tubes can work as well as or better than VHO's if four or more eight-food tubes are used in the garden.

The yield of the garden is difficult to compute because of all the variable that determine growth rate. A conservative estimate for a well-run garden is one ounce of grass (pure smoking material) per square foot of garden every six months.

In commercial grass, the seeds and stems actually make up more of the bulk weight than the useable marijuana.

The grass will be of several grades depending on when and what plant part you harvest. The rough breakdown might be 1/3 equal to Mexican regular, 1/3 considered real good smoke, and the rest prime quality. With good technique, the overall yield and the yield of prime quality can be increased several fold.

5.3 Sources

When sunlight is refracted by raindrops, the light is separated according to wavelengths with the characteristic colours forming a rainbow. Similarly, the white light of electric lights consists of all the colours of the visible spectrum. Electric lights differ in the amount of light they generate in each of the colour bands. This gives them their characteristic colour tone or degree of whiteness.

Plants appear green because they absorb more light near the ends of the visible spectrum (red and blue) and reflect and transmit more light in the middle of the spectrum (green and yellow). The light energy absorbed is used to fuel photosynthesis. Almost any electric light will produce some growth, but for normal development the plants require a combination of red and blue light.

Sunlight has such a high intensity that it can saturate the plants in the blue and red bands, though most of the sun's energy is in the middle of the spectrum. Artificial lights operate at lower intensities; so the best lights for plant growth emit much of their light in the blue and red bands.

Fluorescent Tubes

Several lighting manufacturers make tubes (gro-tubes) the produce much of their light in the critical red and blue bans. (Plant-gro (GE), Gro-Lux (Sylvania), Agro-Lite (Westinghouse), and gro-lum (Norelco) are examples, and they look purple or pink. Vita-lite and Optima (Duro-test) produce a white light with a natural spectrum very similar to daylight. Duro-test blubs are more expensive than other tubes but they last twice as long. {See spectrum for "The action spectra of chlorosynthesis and photosynthesis compared to that of human vision. Adapted from IES Lighting Handbook237"}

Theoretically, these tubes should work better for growing plants than standard lighting tubes. However, some standard or regular fluorescent tubes used for lighting actually work better for growing plants than more expensive natural-spectrum tubes and gro-tubes specifically manufactured for plant growth. The reason is that regular fluorescent produce more light (lumens), and overall lumen output is more important for growth rate than a specific light spectrum. To compensate for their spectrums, use them in combinations of one "blue" fluorescent to each one or two "red" fluorescent (Box B).

Manufacturers use standardised names such as Daylight and Sofwhite to designate a tube that has a certain degree of whiteness. Each name corresponds to a tube that emits light in a particular combination of colour bands. For example, Cool White emits more blue light than other colours and appears blue-white. By combining tubes that emit more blue light with tubes that emit more red light, the tubes

complement each other and produce a more natural spectrum for healthy plant growth. More "red light" than "blue light" sources are needed to foster healthy growth, so use two red tubes to each blue tube.

The best combinations are either Warm White or Soft White (red) tubes used with either Cool White or Daylight (blue) tubes. These four tube types are common, much cheaper, and when used in combination, will give you a better return than any of the more expensive gro-tubes or natural-spectrum tubes. Any hardware store carries these common lighting tubes, and the cost may be less than a dollar each.

Do not use tubes with "deluxe" in their designation. They have a more natural spectrum but emit considerably less light. Preferably, buy "Cool White" since it emits 50 percent more light than "Cool White Deluxe."

Incandescents and Flood Lights

The common screw-in incandescent bulb produces light mainly in the longer wavelengths: far-red, red, orange, and yellow. Higher-wattage bulbs produce a broader spectrum of light than lower-wattage bulbs. Incandescents can be used alone to grow marijuana, but the plants will grow slowly and look scraggly and yellow. Incandescents combined with fluorescent work well, but fluorescent are a better source of red light. Fluorescent tubes generate slightly less heat per watt. With incandescents, heat is concentrated in the small bulb area, rather than the length of the tube, and can burn the plants. In addition, incandescents have less than one-third the efficiency of fluorescent in terms of electricity used. If you decide to use incandescents in combination with fluorescent, use two times the wattage of incandescents to blue source fluorescent, that is, two 40-watt Daylight tubes to about three 60-watt incandescents, evenly spacing the red and blu sources.

The common floodlight has a spectrum similar to but somewhat broader than incandescents. Because they cast their light in one direction and operate at higher intensities, these lights work better than incandescents, both as a single source and to supplement natural or fluorescent light. {Figure 33. Supplement natural light with floodlights. Use foil curtains for reflectors.}

The best application for floodlights and incandescents is to supplement natural and fluorescent light, especially when the plants get larger and during flowering. Incandescents and floodlights require no special fixtures, although reflectors increase the amount of light the plants receive. These lights are easy to hang or place around the sides of any light system, and their strong red band promotes more growth and good flower development. Some of their energy is in the far-red band. Most purple gro-tubes and white fluorescent are deficient in this band, and addition of a few incandescents make them more effective. Agro-lite and W/S Gro-Lux emit adequate far-red light and need no addition of incandescents.

Several companies make screw-in spotlights specifically for plant growth. Two brand names are Duro-Test and Gro n'Sho. Although they are an improvement over incandescents as a single source, these lights don't perform nearly as well as fluorescent. A 150-watt bulb would grow one plant perhaps four feet tall. Two eight-foot fluorescent tubes (160 watts) will easily grow eight six-foot plants. For supplemental lighting, the incandescents and floodlight work as well and are cheaper.

HID Lamps. Metal Halide (MH) and Sodium-Vapour Lamps (HPS)

HID's (High-Intensity-Discharge) are the lamps of choice for serious indoor gardeners. HID lamps commonly illuminate streets, parking lots, and sports stadiums, and they emit very intense light and produce more light, more efficiently than fluorescent. All HID's require specific ballasts and fixtures to operate, so purchase complete systems (fixture, ballast, reflector) along with the lamp. High Times and Sinsemilla Tips magazines (p. 332) feature numerous ads by retailers of horticultural HID systems. Contact the advertisers, and they'll send you brochures with enough information to make an informed choice.

Ordinary metal-halides (MH's and HP's) may emit dangerous UV and particle radiation of the bulb envelop breaks, cracks, or develops a small hole. Broken MH bulbs may continue to operate apparently normally, and exposure may cause serious eye or skin injury. Make sure to purchase MH bulbs designed

with a safety feature (such as GE Sat-T-Gard or Sylvania Safeline) that causes the bulb to burn out immediately if the outer envelope ruptures. OR purchase fixtures that shield the bulb in protective tempered glass.

HID's come in many sizes, but generally, use only 400 and 1,000 watt sized lamps. The largest size (1,500 watts) is not recommended because of its relatively short bulb life. Sizes less than 400 watts do not return as much marijuana considering set-up costs and ease of operation. The only exceptions are certain "self-contained" mini-units of 150 and 175 watts (see 4.1). These mini-self-contained units have a horizontal fixture and built-in ballast, which is easy to set up. The horizontal fixture directs up to 45 percent more light to the plants than conventional, vertically positioned lamps with reflectors. The intense light encourages excellent growth and bud formation with modest electrical consumption. They are the best overall light system for small, personal gardens such as closet set-ups.

Position 400 watt HID lamps 18 to 30 inches above plant tops, and 1,000 watt lamps 30 to 42 inches above the tops. During flowering, flowers may "run" rather than form in compact buds if lamps are positioned too close to the plant tops, particularly when using HPS's.

Heat is the main problem with HID's, and the room must be well-ventilated. Use exhaust fans to draw heat out of the room. The fan doesn't need to be large, just active enough to create a strong, ventilating draft.

Light Balancers

Sophisticated gardeners use light balancers which employ a small motor to move reflectors and HID lamps held on tracks or mechanical arms slowly across a garden in either a linear or circular pattern {(see p. 88 Figure 38b)}. Light balances save considerable power and bulb costs because they dramatically increase the effectively illuminated garden size, while using less the 24 watts per balancer. With the lights moving on a balancer, all of the garden becomes equally illuminated for modest running costs. Instead of adding another 1,000 watt HID, a light balancer increases the garden size without measurably increasing power consumption, an important consideration when electricity consumption or costs are of concern.

With multi-bulb HID gardens, use one MH to each HPS lamp on a light balancer, and hang the lamps about one foot closer to the plant tops than usual. MH's favour blue light, and HPS's produce more orange-red light. By combining the two, the spectrum is more balanced, and you'll get a better return of well-formed buds.

Low Cost HID Systems

By far, the most efficient and effective set-up for a modest artificial light garden is to use fluorescent lamps set on a long photoperiod for germination, growing seedlings or to raise clones; use another room,, or part of the room separated by a light-tight curtain or barrier, for flowering with (HPS) lamps in horizontal reflectors kept on a short photoperiod to induce and promote flowering.

For example, separate and average sized room into two growing areas by hanging an opaque curtain to block light between the two sections. In the smaller area, grow seedling or clones (see 18.5) for two to six weeks under fluorescent set on a constant light. In the larger section, keep HPS lamp(s) on a 12-hour light cycle for flowering. Move larger seedlings under the HPS lamp(s) for about 9 to 15 weeks to initiate and complete flowering. Meanwhile, start more seedling under fluorescent. It's easy to maintain both sections of the room be constantly replenishing either area with new plants. This setup is very productive for a modest investment in both costs and labour - no time or costly light and electricity is wasted on empty space, and you'll find yourself continuously harvesting mature buds.

{A no frills setup with an HID. Notice that the ballast is insulated from the floor with pieces of wood; the fixture is supported by rope and not the electric cord; plastic protects the floor; there is a timer, a reflector, and fan.}
{Figure 34 and 35 for light-output from two and four 40 watt white

fluorescent and comparing effectiveness in footcandles.}

Using this setup, the initial long photoperiod and small area necessary for seedlings or clones is illuminated cheaply by fluorescent. Seedlings grow, and cuttings root, better under fluorescent than HPS's. The larger, more costly flowering section is kept under a short photoperiod of 12 hours of daily light and the strong red light is necessary for good flowering.

For example, the whole operation could draw less then 650 watts: 160 watts by four, four-foot fluorescent set on constant light to start the seedlings; one 400 watt HPS set on 12 hours daily light for flowering; two timers and a venting fan for automating the lights and controlling heat. It's possible to harvest four to six, fully mature crops each year, or continuously harvest. (See Mel Frank's new Marijuana Grower's Insider Guide by RED EYE PRESS for much more information on efficient, low cost, indoor systems and greenhouse gardening.)

5.4 Setting up the Garden

Under artificial light, marijuana grows from three to sic feet in three months, so the height of the light must be easy to adjust. Fixtures can be hung from the ceiling, shelves, walls, or from a simple frame constructed for the purpose. If you are hanging the lights from the walls or ceiling, screw hooks directly into a stud. Studs are located in every room corner and are spaced 16, 18 or 24 inches apart. Light can be supported from lathing using wingbolts, but plaster is too weak to hold a fixture unless a wooden strip held by several wingbolts is attached to the walls or ceiling first to distribute the pressure. Then hang the fixture from a hook in the strip. Closets have hooks and shelves or clothes rungs that are usually sturdy enough to support the fixture. People have gardens under loft beds.

Chains are the easiest means of raising and lowering fixtures. Two chains can be suspended from a solid support from above, and attached to an "S" hook at each end of the fixture. Raise the fixture by inching the hooks to higher links on the chain. Or tie rope to the fixture, pass through an eye hook or pulley in the ceiling or frame, and tie-off at a hook or boat cleat anchored in the wall or frame.

You can also hang the lights permanently and lower plants on a shelf or plywood. The shelf could be suspended or lowered by supporting the shelf with progressively smaller block. This arrangement is often used in "growing factories" where plants are rotated to larger gardens and grow for only a few weeks in each space. One garden may have fluorescent for starting plants and another garden for maturing plants under HID's. With HID's and skylights, lowering the plants may be your best option. Use lightweight soil components or hydroponics rather than heavier soil, and the operation is easier.

If you plan to use six or more fluorescent, remove end sockets and ballasts from fixtures. Mount end sockets and tubes on a frame of one-by-twos or plywood. Space sockets so tubes cover the garden evenly (see Figure 37 and 38). This arrangement illuminates the garden more evenly and drastically reduces the suspended weight since ballasts make up most of a fixture's weight. Keep ballasts off floors and away from water. Mount the ballasts on a nearby wall or on a wooden box. Wet ballasts could actually explode, and at best, are electrically dangerous when wet.

Always buy fixtures with reflectors. For HID's, companies make their own reflectors, but the best reflectors are for horizontally positioned lights no matter which company. Horizontal reflectors focus much more useable light than either parabolic or cone reflectors. HPS's can work in any position, but MH lamps are made to work in either a horizontal or vertical position, and you must buy bulbs that correspond with the fixtures.

For fluorescents, you can make an overhead reflector from the cardboard cartons in which tubes and fixtures are packaged. Cut off the end flaps and form the cardboard into a "U". Face inner side with aluminium foil or paint them white. Leave enough space so the foil or cardboard does not contact end sockets. Staple or tape the reflector behind the tubes to the fixture or from to reflect light toward the plants.

Surround all garden with reflective surfaces, but not so tightly that air can't freely circulate. Even in window gardens, reflective sheets set adjacent to the plants make a marked difference in growth. When

artificial lights are high, reflectors from the floor on up keep lower branches actively growing. Mylar, with its mirror-finish, is popular for facing walls. A flat white paint (super or decorator white) reflects better than glossy white or aluminium foil. Flat white has about three percent more reflecting capacity than aluminium foil, and reflects light more uniformly. The difference is slight, so use whatever means is most convenient. Paint walls that border the garden a flat white or cover them with aluminium, mylar, or white plasterboard. {Figure 36. Reflectors can be made from sturdy paper faced with aluminium foil. Make them with staples, tape, or tacks. Figure 37.}

Natural-light gardens also benefit from reflectors. Make them out of cardboard painted white or faced with aluminium foil. Once the plants are past the seedling stage, surround them with reflectors; otherwise only one side of the plants will be fully illuminated.

Covering the floor with a plastic dropcloth (about $1 at any hardware store) will protect your flor and your neighbour's ceiling from possible water damage.

Marijuana grows well in a dry atmosphere, but heated or air-conditioned homes are sometimes too dry during germination and early growth. Enclosing the garden in reflectors will contain some of the moisture and insure a healthy humidity. White sheet plastic is available to enclose open gardens. Do not completely enclose the garden. Leave some open spaces at the bottom, top and ends of the garden to allow air to circulate. Air circulation will become more important as the plants grow larger.

Don't rely on training your pets to stay out of the garden. The garden will attract them, and they can easily destroy young plants by chewing on leaves and stems. Soil is more natural to their instincts than the sidewalk or kitty litter. Protect the garden from pets and toddlers; surround it with white plastic or chicken wire. Large plants are more sturdy and animals can do them little harm. The jungle ambience and an occasional leaf are irresistible to most cats, and they'll spend hours in the garden.

5.5 Electricity

For most growers, the amount of electricity used is of little concern. A four-tube, regular-output, eight-foot fixture draws about 320 watts per hour or about the same as a colour TV. The cost increase to your electric bill will be about two to six dollars a month, depending on local rates.

Farmers who devote entire basements or attics to their gardens are sometime restricted by the amount of current they can draw. Older homes or apartments may have only one 15-ampere circuit but more often have two, for 30 amperes total. Newer homes have either 60 or 100 amperes available through four to six circuits. One 15-ampere circuit can safely accommodate three, two-tube VHO fixtures or six tubes for 1,290 watts, or 16 regular-output, eight-foot tubes for about 1,280 watts total. This allows for a 20 percent safety margin of circuit capacity, which is necessary considering heat loss, starting voltages, etc.

In kitchen and basements the circuits may be rated higher, at either 20 or 30 amperes. You can find out the amperage of the circuit by looking at the fuse rating on the face of the fuse. Determine what room or rooms each circuit is feeding by removing the fuse and seeing which outlets are not working. The wattage capacity of any circuit is found by multiplying volts time amps. Standard United States voltage is 110 to 120 volts.

Fluorescent light fixtures are sometimes sold unwired or without a line cord, and the job is left to you. Follow the diagram on the ballast which shows the wires marked by their colour. Simply attach the wires to the sockets as diagrammed. New sockets have small holes which automatically make contact when the bare end of the wire is pushed into them. Older fixtures have sockets with conventional screw terminals.

Indoor gardens may have aluminium foil, chains, reflectors, and wet floors, all of which are good electrical conductors. Coupled with hanging lights, these conditions could lead to dangerous electrical shocks. Never touch a reflector, fixture, or ballast while watering or standing on a damp floor. Eliminate the chance of serious shocks altogether by turning off the lights whenever you work in the garden. An HID ballast on a damp floor is very dangerous. Raise HID ballasts on wood blocks off the floor.

Reduce the risk of dangerous shocks by using fixtures grounded to the power source. A fixture with a three-pronged plug connected to a three-wire outlet is grounded in a properly wired house. You can also ground a fixture by connecting a #12 or #14 gauge wire to any bare metal screw (not an electric terminal) on the fixture housing to the screw that holds the cover plate on the electrical outlet your using.

{With two prong outlets, connect an adaptor plug with a terminal (top left) or third wire (top right) from the plug to the screw that holds the cover plate. This converts two-wire outlets to three wire grounded systems when a three-wire electric cord is used, an important electrical safeguard which grounds the light system.}

Chapter Six
SOIL AND CONTAINERS FOR IT

6.2 Pots and Other Containers

In its natural state, marijuana may grow an extensive root system - a fibrous network of fine, lateral roots that branch off a main, carrot-shaped tap root. In dry areas, the tap root can grow more than six feet deep in its search for water. In moist areas with fertile soil (such as in potting mixtures), the lateral roots are able to supply water and nutritive needs and the tap root remains small, often only three or four inches long on a seven-foot-tall mature plant.

The purpose of the growing medium is to provide adequate water and nutrients in addition to anchoring the roots, which hold the plant upright. By watering and fertilising as needed, you could grow a six-foot plant in a four-inch ((Pots are measured by diameter across the top.)) pot or in a three-foot layer of soil over your whole garden; but neither of these extreme procedures is very practical.

Most growers use containers that will hold between two and five gallons of soil. These are a good compromise in terms of weight, space, cost, and labour. They can be moved easily and hold an adequate reservoir of water and nutrients to support a large mature plant.

Some growers use a single large box or several long troughs that hold a six- to 12-inch layer of soil. These have the advantage of minimal restriction of roots and less frequent waterings, but they require more soil and make rotating or moving the plants impractical.

Determine the right size pot to use in your garden by the amount of light per square foot. For a moderately lighted garden (15 to 25 watts per square foot and most window gardens), use one- to three-gallon containers. For gardens with more light energy - over 25 watts per square foot or one-half day or more of sunlight - use three- to eight-gallon containers. The smallest pot we recommend for a full-grown plant is eight inches or one gallon. This is also a good size for starting plants to be transplanted after two months.

Practically any container that can withstand repeated waterings and has a top at least as wide as its base will do. Each pot must have several holes in the bottom to assure drainage. Growers use flower pots, institutional-sized cans and plastic buckets, baskets and small trash cans, milk crates and wooden boxes.

Plastic trash bags are sometimes used when other large containers can't be found. They must be handled carefully, since shifting the soil damages the fragile lateral roots. They are also more difficult to work with when transplanting. However, a roll of trash bags is an available and inexpensive substitute for other large containers. Plastic bags should be double or triple bagged. Small holes should be punched in the bottom to drain excess water. Use masking tape to patch any unwanted tears. The capacity of the bag should be no more than twice as many gallons as the amount of soil used. For example, with four gallons of soil, the bag should be of a five-gallon, but not more than eight-gallon size. Otherwise, it will not form a cylinder, and the bag will remain a shapeless mass.

Use as many pots as can fit in the lighted area to make the most efficient use of space. Many growers

prefer to start the plants in smaller pots, transplanting into larger pots when the plants are larger. There are definite advantages to this method in terms of the yield in the garden, given its space and light energy. Seedlings and small plants take up much les space than they will at maturity, so they can be placed closer together. As the plants grow and begin to crowd each other, remove the less vigorous (to smoke, of course) and transplant the rest into larger pots. Start plants which will be transplanted later in four- to eight-inch flower pots, or one-quart to one-gallon tin cans or milk containers. Peat pots or planting pots are made of compressed plant fibre for the purpose of starting young plants. They are available at garden shops and come in several sizes. Use at least a four-inch pot so that the roots are not restricted in early growth. Peat pots are supposed to break down in the soil, but marijuana's delicate lateral roots may not be able to penetrate unless you score or break away the sides while transplanting. Wax paper cup (six to eight ounces), filled with a soil mixture, work as well as peat pots and are cheaper.

BOX C
Finding Large Containers

Use your ingenuity in finding large containers. Large clay flower pots do not work any better than the large metal and plastic containers discarded by restaurants and food stores. Various milk containers are good starting pots. Many garden shops sell used pots for a few cents each. Wholesalers sell plastic pots by the carton at a discount. Large plastic pots and pails can sometimes be picked up inexpensively at flea markets or variety stores. Any vessel that holds an adequate amount of soil and does not disintegrate from repeated waterings is a satisfactory container.

6.3 Properties of Soil

The soil or growing medium serves as a source and reservoir for water, air, and nutrients, and to anchor the roots. Since marijuana grows extremely fast, it has higher water and nutritive needs than most plants grown indoors. The success of your garden depends on supplying the plant with a medium that meets its needs without creating toxic conditions in the process.

There is no such thing as the perfect soil for Cannabis. Each variety can grow within a range of soil conditions. For healthy, full, growth, marijuana prefers a medium with good drainage, high in available nutrients, and near a neutral pH (7.0). These conditions result from a complex set of physical, chemical and biological factors. We will refer to them simply as: (1) texture; (2) nutrients; (3) pH.

Most indoor growers prepare the growing medium using commercial potting mixes. These mixes are usually sterilised or pasteurised and have good general soil properties. Since they seldom list the contents, nutrients, or pH, do some simple test of your basic soil whether you buy or dig for it. Then you can adjust the soil to meet the basic requirements of the plant.

Texture

The texture of the medium determines its water-holding and draining properties. Marijuana must have a well-drained medium for healthy growth. Soils that hold too much water or hold it unevenly can drown the roots, leading to poor growth or death of the plant. In a well-drained soil the roots are in contact with air as well as water. Soils that have too much clay, or are overly rich in compost or other organic matter, tend to hold too much water and not enough air. This condition worsens in time. This is especially true of the soil in pots.

You can determine the texture of your soil from its appearance and feel. Dry soil should never cake or form crusts. Dry or slightly moist soil that feels light-weight, airy, or spongy when squeezed, and has a lot of fibrous material, will hold a lot of water. Mix it with materials which decrease its water-holding capacity, such as sand, perlite, or even kitty litter.

Wet soil should remain spongy or loose and never sticky. A wetted ball of soil should crumble or separate easily when poked.

Soil that feels heavy and looks dense with fine particulate matter, or is sandy or gritty, will benefit by being loosened and lightened with fibrous materials such as vermiculite, Jiffy Mix, or sometimes sphagnum moss.

Soil Conditioners to Improve Texture

Perlite (expanded sand or volcanic glass) is a practically weightless horticultural substitute for sand. Sand and perlite contribute no nutrients of their own and are near neutral in pH. They hold water, air, and nutrients from the medium on their irregular surfaces and are particularly good at aerating the soil.

Vermiculture (a micaceous material) and sphagnum moss contribute small amounts of their own nutrients and are near neutral in pH. They hold water, air, and nutrients in their fibre and improve the texture of sandy or fast-draining soils. Jiffy Mix, Ortho Mix, or similar mixes are made of ground vermiculite and sphagnum moss, and are fortified with a small amount of all the necessary nutrients. They are available at neutral pH, are good soil conditioners, and are also useful for germinating seeds.

Sphagnum and Peat Moss (certain fibrous plant matter) are sometimes used by growers to improve water holding and texture. Both work well in small amounts (10 to 15 percent of soil mixture). In excess, they tend to make the medium too acidic after a few months of watering. Use vermiculite or Jiffy Mix in preference to sphagnum or peat moss.

Nutrients

Nutrients are essential minerals necessary for plant growth. The major nutrients are nitrogen (N), phosphorus (P), and potassium (K), which correspond to the three numbers, in that order, the appear on fertiliser and manure packages, and that give the percentage of each nutrient in the mix (see section 9).

Marijuana prefers a medium that is high in nitrogen, and mid-range in phosphorus and potassium. Generally, the darker the soil, the more available nutrients it contains. Commercial soils usually contain a good balance of all nutrients and will support healthy growth for a month or two, even in smaller (one gallon) containers. Many growers prefer to enrich their soil by adding sterilised manures, composts, or humus. All of these provide a good balance of the three major nutrients. They also retain water in their fibre. In excess they cause drainage problems, make the medium too acidic, and attract insects and other pests. A good mixture is one part compost or manure to five to eight parts of soil medium. In large pots (four or five gallons), these mixtures might provide all the nutrients the plant will ever need. {Table 13.}

The many prepared organic and chemical fertilisers that can be mixed with the soil vary considerably in available nutrients and concentrations. Used in small amounts, they do not appreciably effect the soil texture. Many prepared fertilisers are deficient in one or more of the major nutrients (see Table 14). Mix them together so there is some of each nutrient, or use them with manures, which are complete (contain some of all three major nutrients). When adding fertilisers, remember that organic materials break down at different rates. It is better to use combinations which complement each other, such as poultry manure and cow manure, than to use either fertiliser alone. (See Table 22 in section 13 for a complete list of organic fertilisers.

Table 14 - Prepared Organic Fertilisers

Type of fertiliser	Percentage by weight of N	P2O5	K20	Availability to Plant
Blood meal	13	0	0	Rapid/medium
Bone meal	0.5	15	0	Medium/slow
Blood/bone meal	6	7	0	Medium/slow
Cottonseed meal	6	2	1	Slow/medium

Fish meal	8	2	0	Slow/medium
Hoof and bone meal	10	2	0	Slow
Rock phosphate	6	24	0	Slow
Wood ash	0	1.5	3-7	Rapid
Greensand	0	0	2-8	Medium/slow

Chemical fertilisers are made in about every conceivable combination and concentration. Pick one that is complete and where the first number (N) is at least equal if not higher than both P and K. For example, rose foods may be 12-12-12 or 20-20-20, and work very well for marijuana. Others are: Vigoro 18-4-5 and Ortho 12-6-6. The higher the number, the more concentrated the mix is, and consequently, the more nutrients are available.

Don't use fertilisers which come in pellets or capsules, or that are labelled "timed" or "slow release." They do not work as well indoors as do standard organic and chemical fertilisers. Chemical fertilisers seldom list the amount to mix per pot. You can get some idea by the instructions for application per square foot. Use that amount of each one-half cubic foot of soil mixture.

Many growers add no nutrients at this time but rely on watering with soluble fertilisers when they water. These fertilisers and their application are discussed in section 9.

pH

The pH is a convenient measure of the acidity or alkalinity of the soil medium. It is another way of expressing whether the soil is bitter (alkaline) or sour (acid). The pH is measured on a scale of 0 to 14, with 7.0 assigned neutral; below 7.0 is acid and above is alkaline.

You can think of the pH as a measure of the overall chemical charge of the medium. It affects whether nutrients dissolve to forms available to the plant or to forms the plant can't absorb, remaining locked in the soil medium.

Marijuana responds best to a neutral (7.0 pH) medium, although in a fertile, well-drained soil, it will grow well in a range of 6.0 to 8.5. The simplest way to check the pH is with a soil-test kit from a garden shop or nursery. Test kits are chemicals or treated papers - for example, litmus papers or Nitrazine tape - that change colour when mixed with a wet soil sample. The colour is then matched to a colour chart listing the corresponding pH. Nitrazine tape is available, inexpensively, in drug stores. Some meters measure pH, but these are expensive. Agricultural agents, agricultural schools, and local offices of Cooperative Extension will test a soil sample for pH and nutrient content. Occasionally, a garden-shop person will check pH for you or will know the pH of the soils they sell.

Highly alkaline soils are characteristically poor soils that form cakes, crusts, and hardpan. Soil manufacturers don't use them, nor should they be dug for indoor gardens. Alkaline soils are treated with sulphur compounds (e.g., iron sulphate) to lower the pH.

We have never seen commercial soils that were too alkaline for healthy growth, but they are sometimes too acidic. The pH of acid soil is raised by adding lime (calcium-containing) compounds. Liming compounds come in many forms and grades. Some are hydrated lime, limestone, marl, or oyster shells, graded by their particle size or fineness. Use the finest grade available, since it will have more of a neutralising potential than a coarse grade. You need to use less and are more interested in immediate results than long-term soil improvement. For indoor gardens, use hydrated lime (available in any hardware store) or wood ashes to raise the pH. Hydrated lime is rated over 90 percent for its neutralising potential. Wood ashes will neutralise soil acids roughly one-half as well as hydrated lime. However, they also contain some nutrients (potassium, phosphorus, magnesium, and micronutrients) and are handy and free.

There is no exact formula we can give you for raising the pH. The pH does not have to be exact; it's and approximation. At low pH it takes less lime to raise the pH one point than it does when the pH is near neutral. Sandy soils need less lime to raise the pH one point than soils high in clay or organic matter. In general, add three cups of hydrated lime or six cups of fine wood ash to every bag (50 pounds or a cubic

foot) of soil to raise the pH one point. For soils that test slightly acid (about 6.5), add two cups of lime or four cups of wood ash.

Soil that tested below 6.0 should be retested in about two weeks, after thoroughly mixing and wetting the soil. Repeat the application until the pH is in an acceptable range. Check the pH of plain water to see if it is influencing the tests. Distilled water is neutral, but tap water sometimes has minerals that can change the pH. Hard water is alkaline. Sulphurous water and highly chlorinated water are acidic.

If you have already added lime to a soil that now tests from 6.5 to 7.0, don't add more lime trying to reach exactly 7.0. Too much lime will interfere with nutrient uptake, notably of potassium, phosphorus, and magnesium.

General Soil Characteristics

The texture, pH, and available nutrients of the soil are all related. The most important single factor is texture (good drainage). When soil drains poorly, it creates anaerobic (without air) pockets in the soil. Bacteria or microbes that live without air will begin to multiply and displace beneficial microbes that need air to survive. The anaerobic microbes break down organic matter to a finer consistency, and release CO2 and organic acids to the medium. Drainage worsens, the acids lower the pH, and nutrients, even though present, become unavailable to the plant.

The result can be a four-month-old marijuana plant that is only three inches tall, especially if you use high concentrations of manures and composts, peat and sphagnum moss. If your soil lists manures or composts as additives, add no more than 10 percent of these on your own.f

Drainage problems sometimes develop after several months of healthy growth. It is a good idea to add about 20 percent sand or perlite to even a well-drained soil. You can never add too much of these; they con only improve drainage. They dilute the nutritive value of the soil, but you can always water with soluble fertilisers.

Mixtures using many components in combination seem to work particularly well. This may be because, at a micro-level each component presents a slightly different set of physical, chemical and biological factors. What the plant can't take up at one point may be readily available at another.

6.4 Preparing Commercial Soils and Mixes

Garden soils (or loams) and potting mixes are actually two different groups of products, although they are frequently mislabelled. Some companies sell soil in large bags and a potting mixture in smaller bags, while labelling them the same. Soils and potting mixtures are usually manufactured locally, since transportation costs are prohibitive; so they differ in each area.

Texture and Nutrients

Soils and loams are usually topsoil blended with humus or compost for use as a top dressing in gardens, for planting large outdoor containers, or for the soil part of a potting mixture. They may have a tendency to compact under indoor conditions and will benefit from the addition of perlite or vermiculite. Soils and loams usually contain a good supply of nutrients and may support a full-grown plant in a large container. Commercial soils that are heavy generally work better than lightweight soils. Heavy soils usually contain topsoil, in which marijuana grows very well. Lightness indicates more fibrous content.

For example of possible soil mixtures, see Box D. pre?

BOX D Examples of Soil Mixtures* 1. 5 parts soil 2. 8 parts soil 2 parts perlite 3 parts sand 1 part cow manure 1/4 part 10-10-10 chemical fertiliser 3. 5 parts soil 4. 4 parts soil 2 parts perlite 1 part sand 2 parts humus 1 part vermiculite 1/2 part cottonseed meal 2 parts humus 1/2 part poultry manure 5. 3 parts soil 6. 6 parts soil 1 part perlite 2 parts perlite 1 part sand 2 parts vermiculite 2 parts Jiffy Mix 1/2 part poultry manure 1/2 part blood/bone meal 1/2 part cow manure 1/2 part wood ash 1 part wood ash *Almost all fertilisers are acidic, and need to be neutralised by lime. For the above mixtures, or any similar ones, mix

in one cup of lime for each five pounds of manure, cottonseed meal, or chemical fertiliser in order to adjust the pH.

Potting mixes are intended to support an average-size house plant in a relatively small pot. They are sometimes manufactured entirely from wood and bark fibre, composts, and soil conditioners. These mixes are made to hold a lot of water and slowly release nutrients over a period of time, which is what most house plants require. For marijuana, these mixes seldom contain enough nutrients to support healthy growth for more than a couple of months. (Their N is usually low, P adequate, and K usually very high.) They work best when sand or perlite is added to improve drainage, and fertilisers are added to offset their low nutrient content.

The pH

Most commercial mixes and soils are between 6.0 and 7.0 in pH, a healthy range for marijuana. If you buy your soil, it will not be too alkaline for healthy growth, but it might be too acidic. You can minimise the chances of getting and acid soil by avoiding soils with "peat" or "sphagnum" in their names. Avoid soils that are prescribed for acid-loving plants such as African violets or azaleas, or for use in terrariums. With common sense, you can buy a soil, add two cups of lime to each large bag, and not have to worry about the pH. However, the surest procedure is to test the pH yourself.

Probably the best way to find the right soil for your garden is to ask long-term growers. They can relate their past experiences with various mixes and blends. Most long-term growers with whom we have talked have tried many of the mixes available in their areas. A reliable, enlightened nurseryperson or plant-shop operator may also be able to give you some advice.

6.5 Buying Soil Components

All the materials discussed here are available at farm and garden stores or nurseries. Many suburban supermarkets sell large bags of soil and humus. Always buy your materials in the largest units possible to reduce the cost.

Large bags of soil and humus come in either 50-pound bags or one- to four-cubic-foot bags. A 50-pound bag fills about six gallons. There are eight gallons to a cubic foot. Perlite is sold in four-cubic-foot bags (thirty-two gallons). Jiffy Mix and vermiculite are sold in four-cubic-foot bags and in 16 pound bags (about 18 gallons). Sand, perlite and vermiculite come in coarse, medium, and fine grades. All grades work well, but if you have a choice, choose coarse. Sand (not beach sand) is an excellent soil conditioner. The only disadvantage is its heavy weight. Buy sand from lumber yards or hardware stores where it is sold for cement work. It will cost from 1/50 to one-half the cost of garden or horticultural sand. Sand from piles at construction sites works very well.

Calculating the Amount of Soil

The maximum amount of soil mixture for any garden can be found by multiplying the capacity of the largest pot you plan to use by the number of pots that you can fit in the garden. In many cases, the actual amount of the mixture used will be somewhat less. Two illustrations follow.

1. A small garden with a two-tube, eight-foot fixture (160W). Using 20 watts per square foot for fast growth gives 160W divided by 20W/sq.ft. + eight sq.ft. The largest pot needed for this system is three gallons, but two gallons would work. You can fit about 10 three gallon pots in eight square feet; so 3 * 10 + 30 gallons of soil mixture are needed (see Box E).

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BOX E
Examples Showing How Much Soil Material to Buy to Fill
a Known Number of Unit-Volume Containers

Example 1.  For a garden eight square feet in size,
Buy             Component         Which amounts to
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 3 50-lb (6 gal. ea. ) bags of  soil    18 gallons
 1 cubic foot of        perlite  8 gallons
30 lbs of       humus    3 gallons
10 lbs of       chicken manure   2 gallons
                TOTAL   31 gallons

Example 2.  For a garden 24 square feet in size,
Buy             Component         Which amounts to

 4 1-cu. ft. bags of    soil    32 gallons
 2 1-cu. ft. bags of    perlite 16 gallons
 1 1-cu. ft. bag of     vermiculite      8 gallons
20 pounds of    cow manure       3 gallons
                cottonseed meal  2 gallons
                wood ash         2 gallons
                TOTAL   63 gallons
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2. A large garden with two two-tube, eight-foot VHO fixtures (four times 215 watts or 860 total watts) illuminating a garden three by eight feet, or 24 square feet.

860 watts divided by 24 sq. ft. = about 36W/sq. ft.

The largest pot size for this system is about five gallons. About 16 five-gallon containers can fit in 24 square feet; so 16 * 5 + 80 gal. of mixture are needed. But you could start many more plants in smaller containers and transplant when they are root-bound. You do not use more soil by starting in smaller pots, since all soil is reused. In many cases, you actually use much less soil.

In this system you could start and fit about 40 plants in one-gallon pots in 24 square feet. When the plants begin to crowd each other, some are harvested, making room fir the others, which are transplanted to larger pots. In practice, a high-energy system such as this one (36W/sq. ft.) will grow large plants whose size is limited mainly by the space available. Twelve large female plants are about the most you would want in the system during flowering and for final harvest. Sixty gallons of mixture is all that is needed for the seedlings and the mature crop. This is one-fourth les than the original estimate of 80 gallons, and you actually will harvest a lot more grass (see Box E).

Mixing and Potting

Mix your soil in a large basin, barrel, or bathtub. Individual pots are filled with mixtures by using a smaller container to measure out by part or volume.

Perlite, sand, and dry soil can give off clouds of dust. When mixing large amounts of these, wear a breathing mask or handkerchief over your nose and mouth.

To pot any of the mixtures, first cover any large drainage holes with a square of window screen or newspaper to prevent the mixture from running out. Place a layer of sand, perlite, or gravel about one inch deep to insure drainage. Fill the pots with soil mixture to within three-fourths of an inch from the top of the pot. If your mixture contains manures or composts, cover the last inch or two in each pot with the mixture minus the manure and compost. This will prevent flies, gnats, moulds, and other pests from being attracted to the garden. Press spongy soils firmly (not tightly) to allow for more soil in each pot; otherwise, after a period of watering, the soil will settle and the pot will no longer be full.

Some growers add a few brads or nails to each pot to supply the plant with iron, one of the necessary nutrients. Water the pots and allow them to stand for a day or two before planting. As the soil becomes evenly moist, beneficial bacteria begin to grow and nutrients start to dissolve. {Figure 40.}

6.6 Digging Soil

Most growers prefer to buy their soil, while some prefer to dig it. Marijuana cannot tolerate heavy clays, mucks, or soils that dry to crusts. Choose a soil from a healthy garden or field, or from an area that supports a lush growth of annual weeds.

Fields that support a good crop of alfalfa, corn or other grains will support a good crop of marijuana. Fields with beets, carrots, and sugar cane indicate a well-drained soil, with near neutral pH. Red clover, sweet clover, and bluegrass have soil requirements similar to those of marijuana. Garden soils are usually fertile and well-drained, but often need lime to counteract soil acidity.

Take the topsoil layer that starts about two inches below the surface debris. Good soil will look dark, feel moist, and small clean and earthy. Use all of the topsoil layer that maintains its dark colour and is interlaced with roots. Your hands should be able to easily penetrate the underlying topsoil if the soil is in good condition. When the soil changes colour, or roots no longer apparent, then you are past the fertile topsoil layer. Abundant worm, millipedes, and other small lifeforms are a good indication that the soil is healthy. A rich layer of topsoil collects by walls, fences, and hedges where leaves and debris collect and decay to a rich humus. Sift the soil to remove stones and root clods. Also, shake out the root clods, which are rich in nutrients.

Soil that is dug should be tested the same way as already prescribed. It should be adjusted with at least 30 percent sand or perlite (vermiculite for very sandy soils), since potting will affect the drainage of even well-drained soils. Never use manures or composts that are not completely degraded to a clean-smelling humus.

Soil that is dug must be sterilised to kill weed seeds, insect eggs, and harmful moulds and fungi. Some chemical treatments (e.g. formaldehyde) are mixed with water and poured over the soil to sterilise it. Soil can be sterilised in a pressure cooker at 15 pounds pressure for 15 minutes, or by baking wet soil in a large pot at 200 degrees for 30 to 40 minutes. Be advised that baking soil will release some formidable odours.

6.7 Growing Methods

As we said before, there are probably as many growing methods as there are marijuana growers. These methods are personal preferences or adaptions to fit particular situations; one method is not necessarily better than any other. However, the value of a garden is often based on the amount of high-quality grass it yields. Since indoor gardens are limited in size, you want the plants to quickly fill the garden with lush growth in order to use the garden efficiently. Otherwise, for the first couple of months, the lights are shining on empty space.

Secondly, the possession of small quantities of marijuana will probably be decriminalised nationally within the next few years. Decriminalisation for personal possession will open the way for decriminalisation for cultivation for personal possession. But small quantities are more difficult to define for cultivation than for simple possession, which is done by weight. Several possible ways to limit the amount for cultivation have been raised: by the number of plants, by the area cultivated, or by the number of plants at a particular stage of development. The outcome may determine whether you try to grow the largest plants possible or the most plants possible in a given area.

There are several ways to increase your garden's yield.

1. Pinch or cut back the growing shoots when the plants are young. This forces each plant to develop several strong growing shoots and generally yield large robust plants.
2. Plant a number of plant in each pot.
3. Start many plants in small pots and transplant the best plants to larger pots when the plants crowd each other.
4. Use different light systems to grow plants at different growth stages.

Here are some examples of how to carry out each of these four methods.

1. Fill the growing area with large containers (about five gallons each). Start several plants in each pot but thin the seedlings over a period of six weeks to two months, until one plant is left in each pot. During the fourth or fifth week of growth, pinch back the plants to about equal heights. Cut the growing shoot at about the fourth internode. Each plant will develop a sturdy stem which will support four to eight growing stems and will quickly fill any empty space in the garden. The whole garden is the treated like a hedge. After another month or two, you cut back the growing shoots again to have plants of equal heights. Remove the male plants as soon as they begin to release pollen (or before any male flowers open for sinsemilla). This will leave more space and light for the females to develop. By the time females flower, they've been cut back two or three times or more, and form a dense growth of growing shoots that fill the garden with a cubic layer of flowers. Some growers maintain the plants for up to a year before the final harvest.

{Figure 41. Plant clipped at fourth internode.}

2. This method also requires large pots. Instead of thinning the seedlings to leave one per pot, leave at least three. After a few months of growth, remove any plants that lag far behind or any plants that show male flowers. The value of this method is that the odds are at least seven to one that any pot will have at least one female plant.

Most of the plants you'll grow will fill out with branches by four months at the latest. Often the branches develop young seedlings. The plants may begin to look like small Christmas trees by the second to third months of growth.

Generally, you don't want to have more than three or four plants in a five-gallon container, because growth will be limited by competition for light and space.

{Figure 42. Basement growing factory in Atlanta.}

Some varieties never do fill out. The branches remain small, only two to three inches long, and yield very little grass. We've seen plants like this grown from grass from Vietnam, Thailand, Afghanistan, and Africa. These plants are also quite short, being four to six feet tall fully grown. With varieties like this, it is better not to pinch tops, and to start about six plants per square foot of garden space. At harvest, the garden will be crowded with top stems that are laden with flower clusters.

Of course, you don't know what varieties will look like until you've seen them grow. For most varieties, each plant will need at least one square foot or space at maturity. It is much less common to find varieties that naturally grow small or especially thin, and, therefore, are those of which you would want to plant more than a few per large pot.

3. Another popular way to grow is to start plants in a large number of small pots. As the plants crowd each other, some are removed and the rest transplanted to larger pots.

4. To get the most for your investment requires conservation of light and soil. When the plants are young, a large number fit into a small place. Some growers take advantage of this fact by having several light systems, each with plants at different growth stages. The plants are rotated into larger gardens and pots. This method conserves space, materials, and electricity, and yields a harvest every two months. Using this method, "growing factories" turn out a steady supply of potent grass. {Table 15.}

Chapter Seven
MAINTAINING THE CORRECT ENVIRONMENT

7.2 Requirements for Germination

Before the seed fell, almost all of its water was sapped to prepare the seed for winter. With only the tiny drop that it holds, the embryo lives a life so slow as to be outside of time as we know it. Cannabis seeds need only water to germinate or sprout. The seeds germinate without light and at temperatures low enough to form ice. Higher temperatures hasten germination. Fresh, homegrown Oaxacan seeds germinated in three days at 70F and in eight days at 33F. Temperatures 70 to 90F are best for germination.

Fresh, mature seeds have a high rate of germination (about 90 to 100 percent) and sprout quickly. Usually sprouts appear three to seven days after planting. Older seeds (over a year, depending on storage) have a lower rate of germination and respond slower. They may take up to three weeks to sprout. To get an idea of what to expect from the seeds follow the procedure in 3.1.

Seeds that do sprout will grow normally, no matter how old they are or how long they take to sprout. From any batch of seeds, most of the ones that sprout will do so within two or three days of each other. A few will continue to come up as many as six months later, but the garden should consist of plants that are basically the same age and size. This makes the garden easier to care for.

Choosing Seeds

Different varieties grow at different rates and attain different sizes and shapes. Under artificial lights, gardens plants from one batch of grass require the least attention, because the plants sprout and grow uniformly and can all be tended at the same time. When several varieties are grown together, some plants are taller than others; you must adjust the height of the plants to keep the marijuana equally illuminated. You may also have to water and fertilise the plants on an individual basis. Some growers start at different varieties under separate light systems. On the other hand, planting several varieties offers you a comparison in potency and yield, and a source for hybrids if you want to develop seed. The next time you plant you'll know which seeds gave the best results and what growing methods will work best for you. {Figure 43. Within each seed lies and embryo.}

There is no strict correlation between the form and height of the plants and seed size, colour, or pattern. However, some large-seeded varieties grow too tall, with long spaces between leaves. Under artificial lights they yield more stems than leaves. If you have a choice between two equally potent grasses, and one has particularly large seeds (3/16 to 1/4 inch), choose the smaller-seeded variety.

Sowing

The easiest way to start the plants is to sow the seeds directly into the soil. First, wet the soil with a moderate amount of water, enough to wet the soil with a moderate amount of water, enough to get the soil evenly moist without water running out the bottom. This takes about one-half quart of water for one-gallon containers, and about one quart for three-gallon containers. Plant the seeds a quarter- to half-inch deep. The germination rate is lower when they are planted deeper; and if seeds are planted less then one-quarter inch deep, the sprouts may have difficulty anchoring their roots. Plant about six seeds per pot to assure some sprouts in each pot. Gently press each seed into the soil. Cover the seeds with soil and sprinkle lightly with water. Each day, sprinkle or spray the surface with enough water to thoroughly wet the top half-inch of soil, since the seed must be kept moist for germination.

For most people, germinating the seed is easy. Problems with germination come from either too much or too little water. If you saturate the pots with water, and especially if you continue to saturate the pots after the seeds have sprouted, the seedlings may develop stem rot or root problems. When stem rot develops, the base turns brown, and the seedlings fall over, ending the garden. This can also happen if you keep seedlings in germination boxes or terrariums where the humidity is very high. When the humidity is low, the soil surface dries out quickly and the seeds won't germinate. Sprouts that may come up shrivel and dry at the base of the stem and die.

The key to germination is to keep the soil surface moist after first having moistened the whole pot; then,

after the first sprouts have been up for a few days, let the surface of the soil dry between waterings. Don't spray the surface any more. Water with medium amounts of water when the soil in the top couple of inches feels dry. For small pots, water seedlings about twice a week. For larger pots, once each week or two may be enough.

Some growers prefer to plant only seeds they know will sprout, especially when planting seeds which have a low viability. Start the seeds in wet towels or a glass of water. Add one teaspoon of liquid bleach (a three-percent solution) to each cup of water. This will prevent fungus from attacking the seeds, which happens when they are soaked for more than three days. Check the seeds each day. Plant when the radical or roots begins to come out from the pointed end of the seed. Cannabis seed is quite small and has only enough stored food for the embryo to anchor its root and raise its cotyledons. The more developed the root is when planted, the less energy it has to anchor itself in the soil. The sprout may die or growth be delayed until the root is established (transplant shock). In Figure 44, the seeds in a circle are all ready to plant. The centre seed will not survive transplanting. {Figure 44. Seeds in a circle are ready to plant. Centre sprout will not survive planting

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{**Centre sprout too large**}}
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Some growers prefer to start the plants in a germination box. This extra hassle is not necessary. Transplanting seedlings from one medium to another often causes transplant shock. It is best to plant the seeds directly into the soil.

If you use Soilless mixtures, your seedlings should be started in paper cups, peat pots, or other small pots filled with a soil mixture (see "Transplanting" in Chapter 8 {8.3}). This procedure is also helpful if you have the difficulty starting the plants in large containers. Expandable peat pellets also work very well.

The position of the seed in the soil has a slight effect on germination. The root directs its growth in response to gravity, as shown in Figure 45. However, germination is a little faster when the seeds are planted with the pointed end up. The difference is small, and it's not really necessary to position the seeds in the soil.

If a dry atmosphere presents problems, you can create the moist atmosphere of a germination box and still plant directly in the pot. Cover the seeds with transparent plastic cups or glasses, or cover the pot with plastic kitchen wrap. This creates a greenhouse effect and keeps the soil surface moist without watering. Remove all the covers as soon as you see the first sprouts begin to appear; the sprouts will die if the cover is left on. {Figure 45. The root directs its growth toward gravity. Seeds are germinated between glass and cotton, and held vertically. Four seeds to left have pointed and up. Two middle seeds are horizontal. Sex seeds on right have pointed end down.} {Figure 46. During germination soil can be kept moist by using plastic covers to create a greenhouse effect.}

7.3 Light Cycle and Distance of Lights from Plants

The seed doesn't need light to germinate. The sprout does need light as soon as it breaks through the soil. Most growers turn the light on when they sow the seeds, though, to warm the soil and encourage germination. Lights may also dray the surface of the soil, especially in large pots or with VHO fixtures. If this is a problem during germination, leave the lights off until you see the first sprout breaking through the soil; or hang the lights about 18 inches above the soil, and lower them to six inches as soon as the sprouts appear.

It is important for normal development that the plants receive a regulated day/night cycle. We emphatically recommend that you use an automatic electric timer (about $8). A timer makes gardening much easier, since you don't have to turn the lights on or off each day. The plants won't suffer from irregular hours or your weekend vacations. Set the timer so that the plants get about 16 to 18 hours of light a day, and leave it on this setting until the plants are well grown (three to six months) and you decide to trigger flowering.

During the seedling and vegetative stages of growth, the plants may be subjected to light during their

night period. During flowering, however, the night period must be completely dark.

The plants grow more slowly with less than 16 hours of artificial light a day, and they may flowers prematurely. Some growers leave the lights on up to 24 hours. A cycle longer than 18 hours, may increase the growth rate, especially if the plants are not saturated with light. A longer cycle is helpful in small gardens, such as under standard four-foot fixtures.

No matter what the light source, place the lights as close to the tops as possible without burning the plants. Pay no attention to the manufacturer's instructions for the distance of the plants from the lights; these instructions don't apply to a high-energy plant such as Cannabis. With standard-wattage tubes, keep the lights from two to six inches above the plant tops. With VHO tubes, allow four to eight inches. Maintain the lights at these distances throughout the life of the garden. In most cases you will have to raise the lights once or twice a week as the plants grow.

Standard fluorescents don't get hot enough to burn the plants unless they are in direct contact with leaves for several hours. VHO tubes will burn leaves before they touch them. But you do want to keep the lights as close to the plants as possible. This encourages stocky, robust growth. Incandescents and floodlights get very hot; place them at a greater distance from the plants. Test the distance by feeling for heat with your hands. Place the bulb at the distance where you begin to feel its heat. For a 75-watt incandescent lamp, this is about eight inches.

7.4 Water

Water, the fluid of life, makes up more than 80 percent of the weight of the living plant. Within the cells, life processes take place in a water solution. Water also dissolves nutrients in the soil, and this solution is absorbed by the roots. About 99 percent of the water absorbed passes from the roots into the conduits (xylem) of the stem, where it is distributed to the leaves via the xylem of the leaf veins. Transpiration is the evaporation of water from the leaves. The flow of water from the soil, through the plant to the air, is called the transpiration stream. Les then one percent of the water absorbed is broken down to provide electrons (usually in the form of hydrogen) which, along with carbon dioxide, are used to form carbohydrates during photosynthesis. The rest of the water is transpired to the air.

Watering

Water provides hydrogen for plant growth, and also carries nutrients throughout the plant in the transpiration stream. However, it is not true that the more water given a plant, the faster it will grow. Certainly, if a plant is consistently under-watered, its growth rate slows. However, lack of water does not limit photosynthesis until the soil in the pot is dry and the plant is wilting.

The amount of water, and how often to water, varies with the size of the plants and pots, soil composition, and the temperature, humidity, and circulation of the air, to name a few variables. But watering is pretty much a matter of common sense.

During germination, keep the soil surface moist. But once the seedling are established, let the top layer of soil dry out before watering again. This will eliminate any chance of stem rot. Water around the stems rather than on them. Seedlings are likely to fall over if watered roughly; use a hand sprinkler.

In general, when the soil about two inches deep feels dry, water so that the soil is evenly moist but not so much that water runs out the drainage holes and carries away the soil's nutrients. After a few trials, you will know approximately how much water the pots can hold. Marijuana cannot tolerate a soggy or saturated soil. Plants grown in constantly wet soil are slower-growing, usually less potent, and prone to attack from stem rot.

Over-watering as a common problem; it develops from consistently watering too often. When the plants are small, they transpire much less water. Seedlings in large pots need to be watered much less often than when the plants are large or are in small pots. A large pot that was saturated during germination may hold enough water for the first three weeks of growth. On the other hand, a six-foot plant in a six-inch pot

may have to be watered every day. Always water enough to moisten all the soil. Don't just wet the surface layer.

Under-watering is less of a problem, since it is easily recognised. When the soil becomes too dry, the plant wilts. Plant cells are kept rigid by the pressure of their cell contents, which are mostly water. With the water gone, they collapse. First the bottom leaves droop, and the condition quickly works its way up the plant until the top lops over. If this happens, water immediately. Recovery is so fast, you can follow the movement of water up the stem as it fills and brings turgor to the leaves. A plant may survive a wilted condition of several days, but at the very least some leaves will drop.

Don't keep the pots constantly wet, and don't wait until the plant wilts. Let the soil go through a wet and dry cycle, which will aerate the soil and aid nutrient uptake. Most growers find that they need to water about once or twice a week.

When some soils get particularly dry, the water is not absorbed and runs down the sides and out the bottom of the pot. This may be a problem the first time you water the soil, or if you allow the soil to get very dry. To remedy, add a couple of drops of liquid detergent to a gallon of water. Detergent acts as a wetting agent and the water is absorbed more readily. First water each pot with about one cup of the solution. Allow the pots to stand for 15 minutes, then finish watering with the usual amount of pure water.

Use tepid water; it soaks into the soil more easily and will not shock the roots. Try to water during the plant's morning hours. Water from the top of the pot. If you do want to water from the bottom with trays (not recommended), place a layer of pebbles or gravel in the trays to insure drainage. Don't leaves the pots sitting in water until the pot is heavily saturated. The water displaces the soil's oxygen, and the plants grow poorly.

Tap water in some areas highly chlorinated, which does not seem to harm Cannabis; and many fine crops are raised with water straight from the tap. But chlorine could possibly affect the plants indirectly, by killing some beneficial micro-organisms in the soil. Chlorine also makes the water slightly acidic. However, neither effect is likely to be serious. Some growers have asked whether they should use pet-shop preparations that are sold to remove chlorine from water in fish tanks. These preparations generally add sodium, which removes the chlorine by forming sodium chloride (table salt). This solution does not harm the plants, although repeated use may make the soil too saline. Probably the best procedure is to simply allow the water to sit in an open container for a few days. The chlorine is introduced to water as the gas Cl_2, which dissipates to the air. The water temperature also reaches a comfortable level for the plants.

Hard (alkaline) water contains a number of minerals (e.g., Ca^{++}, Mg^{++}, K^{+}) which are essentially nutrients to the plants. Water softeners remove these minerals by replacing them with sodium, which forms slightly salty water. It is much better to water with hard water, because artificially softened water may prove harmful after some time. Occasionally, water may be acidic (sulphurous). Counteract this by mixing one teaspoon of hydrated lime per quart water and watering with the solution once a month.

Water and Potency

We've seen no studies that have evaluated potency in relation to water. A few studies have mentioned the fact that plants that received less water were slightly more potent. Water stress has been practiced by several marijuana-growing cultures. In parts of India, watering is kept to a minimum during flowering.

To limit watering, water with the usual amounts but as infrequently as possible. To encourage good growth, yet keep watering to a minimum, wait until the plants are a few months old before you curtail watering. Give the plants their normal water and note the number of days before they begin to wilt. As the plants get larger, the water needs increase, but this generally stabilises by the time of flowering.

7.5 Air

The properties of the air seldom present any problems for indoor gardeners. The plants grow well under the ordinary conditions that are found in most homes and can withstand extremes that are rarely found

indoors. The plants can survive, in fact thrive, in an atmosphere many house plants can't tolerate. For plant growth, the most important properties of the air are temperature, humidity, and composition.

Temperature and Growth Rate

Temperature control should be no problem. The plants can withstand temperatures from freezing to over 100F. Plant growth is closely related to temperature. Marijuana varieties are, in general adapted to warm if not hot climates. Different varieties will reach their maximum rate of photosynthesis at different temperatures. For almost all marijuana varieties, the rate of photosynthesis will increase sharply with increases in temperatures up to about 70F. Some strains reach their peak rate of growth at about &%F. Others, especially from areas near the equator, such as Colombia, may not reach their peak rate until the temperature is about 90F. However, for all varieties, increases in the growth rate will be slight with increased temperatures over 75F. The average temperature for maximum is about 75 to 80F. In other words, normal household temperatures are fine for growing marijuana and no special temperature control is necessary for most gardens.

Don't set up the garden right next to, or in contact with, a heat source such as a radiator or furnace. If the garden is nearby, the plants should do quite well. The plants are most susceptible to cool temperatures during germination and the first few weeks of growth. In basement gardens, the floor temperature is often lower than the air. It is a good idea to raise the pots off the floor with pallets or boxes. The seeds will germinate quicker, and the plants will get off to a faster start.

If heating is necessary, propane catalytic heaters work well, are safe and clean, and increase the carbon-dioxide content of the air. Electric and natural gas heaters also work well. Do not use kerosene or gasoline heaters. They do not burn cleanly, and the pollutants they produce may harm the plants. Any heater that burns a fuel must be clean and in good working order. Otherwise, it may release carbon monoxide, which is more dangerous to you than to the plants.

Temperature and Potency

Since marijuana varieties are most often grown in semi-tropical and tropical areas, the idea that high temperatures are necessary for potent marijuana is firmly entrenched in marijuana lore. This myth, like many others, is slowly disappearing as marijuana farmers and researchers accumulate more experience and knowledge. There are only a few published papers on the effects of temperature on potency. The best study we've seen 19 grew four different varieties in a controlled environment under artificial lights on a 15-hour day-length. Two temperature regimes were used: a "warm" regime, with temperatures of about 73F during the day and 61F at night (about average for most homes); and a "hot" regime, set at 90F daytime and 73F at night. In all four varieties, the concentration of THC and of total cannabinoids was higher under the "warm" regime. For instance, a Nepalese strain was 3.4 times higher in concentration of total cannabinoids, and 4.4 times higher in THC, when grown under the "warm" regime than the same strain grown under the "hot" regime. Although we agree with the findings in principle, these figures are higher than our experience tells us.

Interpretation of the data does show one point clearly. In all four varieties, the amount of THC lost as CBN was higher under the "hot" regime (see Table 16 - currently excluded from this guide), even though the concentration of THC was higher under the "warm" regime.

Another research group in France has looked at the relationship of potency to temperature. The most recent paper 79 compared four temperature regimes, given in descending order of potencies found: 75F day, 75F night (highest potency); 72F day, 54F night; 81F day, 81F night; and 90F day, 54F night (lowest concentration of THC). In each, the day period was 16 hours and the night period eight hours.

Interestingly, this same research group in an earlier paper 20 reported that the concentration of THC was higher for male plants grown at 90-72F then for those grown at 72-54F. For the female plants, the differences in THC concentration were small. The variety used was a propyl variety (type IV) containing about half as much THCV as THC. For both the male and female plants, the concentration of THCV were high under the 90-72F regime.

The simplest interpretation of all these results is that mild temperatures seem to be optimum for potency. Temperatures over 90F or below 60F seem to decrease the concentration of THC and total cannabinoids. Also, at higher temperatures, much more THC will be lost as CBN. And last, propyl varieties may produce less THCV under a cool regime. Bear in mind that none of these papers accounted for all of the many variables that could have affected the findings. For instance, the concentration of THC was 18 times higher at 75-75F than at 90-54F. We've never seen differences of this magnitude, and sampling error undoubtedly influenced the findings.

In terms of growth rate and potency, daily temperatures of about 75F, give or take a few degrees, are roughly optimum. Normal household temperatures are in the low 70's during daytime and the low 60's at night. The heat from a light system will raise the garden's temperature a few degrees. In most gardens temperatures will be near 75F during the day. Night-time temperatures drop about 10 to 15 degrees. When night-time temperatures drop into the 50's or below, set the light cycle to turn on during the early morning, when the temperature will be lowest. In a small room, the light system will generate enough heat to warm the garden without any need for a heater. Whenever you wish to raise the temperature by, say, five or 10 degrees, it is better to add more lights than a heater. The plants will benefit from the additional light, as well as from the heat they generate. And an electric heater, watt for watt, doesn't generate much more heat than a lamp and its fixture.

Composition of the Air

Air provides two essential ingredients for the living plant: oxygen and carbon dioxide. The plant uses oxygen for respiration in the same way we do. The oxygen is used to burn carbohydrates (CH2O) and other food, yielding energy (ATP; see section 4) for the organism, and releasing carbon dioxide and water into the environment.

During photosynthesis, CO2 is used to form carbohydrates. As part of photosynthesis, light energy is used to split water molecules, releasing oxygen into the environment. In plants, the net result from respiration and photosynthesis is that much more oxygen is released than consumed, and more carbon dioxide is consumed than released. The oxygen in the Earth's atmosphere is formed by photosynthetic organisms.

The similarity between plant and animal respiration ends at a cellular level. Plants don't have lungs to move the air. The passage of gases, whether oxygen or carbon dioxide, is primarily a passive process. The gases diffuse through microscopic pores called stomata, found in Cannabis on the undersides of the leaves. The plants can open and close their stomata, allowing moderate control of the flow of air. However, for good exchange of gases, the plants require adequate ventilation for air circulation. {Cannabis is a C3 plant}

Cannabis is not particularly susceptible to a stuffy or stagnant atmosphere. A garden in the corner of a room that is open to the house will be adequately ventilated. Ventilation is not a problem unless the garden is large and fills a quarter or more of the space in a room. Gardens in small, confined spaces such as closets, must be opened daily, preferably for the duration of the light period. Plants growing in a closed closet may do quite well for the first month, but they'll need the door opened as the plants begin to fill the space. The larger the plants get, the greater the need for freely circulating air.

When the weather is mild, an open, but screened, window is the best solution for ventilation. In large indoor gardens where there isn't much air circulation, a small fan is helpful. After germination, make spaces in the surrounding reflectors to allow air to circulate freely. Leave the spaces at the bottom, ends, and the tops of the garden. The higher the temperature or the humidity, the more the plants need good ventilation.

CO2

CO2 is a natural, non-poisonous gas present in the atmosphere, which plants absorb and use during photosynthesis to synthesise sugars and organic compounds for energy and growth. Plants can effectively use CO2 up to about .15 percent concentration, about five times the concentration (.03)

naturally present in the atmosphere. Increasing the CO2 dramatically increases the growth rate, often up to twice the rate of growth in plants in a natural atmosphere. Supplemental CO2 systems are an inexpensive way serious gardeners dramatically increase a garden's yield. {And decrease fire risk.} {Picture Common emitter systems are safe, inexpensive, easy to setup, and may double the rate of growth in a garden.}

There are two good ways to increase the concentration of CO2. Greenhouse growers use CO2 generators which produce CO2 by burning a clean-burning fuel such as propane or butane. The problems with CO2 generators are that they require a fuel, operate with an open flame, and produce a lot of heat. These are not necessarily problems if the grow room needs to be heated, and if the room is constantly monitored.

For home-growers, the emitter system is more efficient, relatively cheap, safe, and easy to use. Many suppliers who advertise in High Times and Sinsemilla Tips offer complete emitter systems that come with a regulator, solenoid valve, flow-meter, timer, (sometimes distribution tubing), and detailed, yet simple instructions. You must rent compressed CO2 gas tanks from a local compressed gas supplier or beverage company. The setup is not complicated or expensive, and a walk through the Yellow Pages should show several suppliers.

Since the CO2 in the atmosphere is about .03 percent, and the maximum CO2 concentration that your plants use is about .15 to .2 percent, set your emitter system to regulate a concentration of .12 to .17 percent CO2 in the room. Don't worry if you don't understand. All systems are easy to install and come with easily understood instructions.

7.6 Humidity

Marijuana flourishes through a wide range of relative humidity. It can grow in an atmosphere as dry as a desert or as moist as a jungle. Under ordinary household conditions, the humidity will rarely be too extreme for healthy growth. The effects of the humidity on plant growth are closely tied to temperature, win speed, and the moisture of the soil.

The relative humidity affects the rate of the plant's transpiration. With high humidity, water evaporates from the leaves more slowly; transpiration slows, and growth slows also. With low humidity, water evaporates rapidly; the plant may not be able to absorb water fast enough to maintain an equilibrium and will protect itself from dehydration by closing its stomata. This slows the transpiration rate and growth also slows. There is a noticeable slowing of growth because of humidity only when the humidity stays at an extreme (less then 20 percent or over 90 percent).

Cannabis seems to respond best through a range of 40 to 80 percent relative humidity. You should protect the plants from the direct outflow of a heater or air conditioner, both of which give off very dry air. During the first few weeks of growth, the plants are especially susceptible to a dry atmosphere. If this is a problem, loosely enclose the garden with aluminum foil, white sheet plastic, or other materials. This will trap some of the transpired moisture and raise the humidity in the garden. Once the seedlings are growing well, the drier household atmosphere is preferred.

Where the humidity is consistently over 80 percent, the plants may develop stem rot or grow more slowly. Good air circulation from open windows or a small fan is the best solution.

As long as the air is freely circulating, the plants will grow well at higher humidities. Dehumidifiers are expensive (over $100) and an extravagance.

Humidity and Potency

As far as we know, there has been little work done correlating the relative humidity with potency. In the two related cases we've seen, 85, 117 neither study was intended to examine the effects of relative humidity and potency. However, a lower humidity (50 to 70 percent) produced slightly more potent plants than a higher relative humidity (80 percent and over).

A dry atmosphere seems to produce more potent plants. When the humidity is about 50 percent or less, plant development is more compact, and the leaves have thinner blades. When the atmosphere is humid, growth is taller and the leaves luxuriant with wider blades. The advantage to the plant is that wider blades have more surface and hence can transpire more water. The converse is that thinner blades help conserve water. Higher potency may simply be due to less leaf tissue for a given amount of cannabinoids and resin glands.

The temperature also influences the form and size of the leaves. At higher temperatures, the leaves grow closer together; under a cool regime, the leaves are larger, have wider blades, and are spaced farther apart 77. Possibly, cool temperatures yield slightly lower potency for much the same reason that a moist atmosphere does.

However, differences in potency caused by any of the growth factors (light nutrients, water, temperature, humidity, etc.) are small compared to differences caused by the variety (heredity) and full maturation (expression of heredity). For example, the humidity in Jamaica, Colombia, Thailand, and many other countries associated with fine marijuana is relatively high and averages about 80 percent.

However, try to keep the atmosphere dry. The atmosphere in heated or air-conditioned homes is already dry (usually 15 to 40 percent). For this reason, many growers sow so that the plants mature during the winter if the home is heated or in mid-summer if it is air-conditioned. As we mentioned, there should be no need to use dehumidifiers. Good air circulation and raising the temperature to 75 to 80F are the simplest means of dealing with high humidity.

Chapter Eight
GARDENING TECHNIQUES

8.2 Thinning

Depending on the viability of the seeds, there should be several plants growing in each pot. Most growers thin to one plant per pot, but the plants don't have to be thinned until they crowd each other and have filled the garden with foliage. The longer you let them grow, the more potent they'll be.

It is virtually impossible to tell the gender of the plants when they are young. The normal ratio of males to females in Cannabis is one to one. Some farmers end up wit more male plants because of their thinning practices. When the plants are less than a month old, the male plants often appear taller and better developed than the females. The male seedling uses more of its energy to develop its aboveground parts than the female. The female devotes more energy to establishing a strong root system. During the first few weeks, don't thin the plants by leaving only the tallest, or you'll wind up with a higher ratio of males. Try to leave seedling that are healthy and vigorous and that are roughly at the same point of development.

To thin your garden, remove any plants with yellow, white, or distorted leaves. Remove the less vigorous and those that lag far behind in development. Cut the unwanted plants near the base; the root system can remain in the pot.

These harvested seedlings will be your first taste of homegrown grass. Usually they produce a mild buzz, but if you separate the growing tips from the large leaves, they may be more potent.

8.3 Transplanting

However you transplant, try to disturb and expose the roots as little as possible. If you transplant carefully, the plants will not exhibit delayed or slowed growth due to transplant shock.

Transplanting Seedlings

When the plants are a week to two weeks old, transplant to any pot that has no plants. First, moisten the soil in the pot from which you will remove the transplant and let is sit for a few minutes. Take a spade or a large spoon, and insert it between the transplant and the plant that will be left to grow. Try to leave at least one inch of space from spoon to stem. Lever the spoon toward the side of the pot, in order to take up a good-size wedge of soil. Place the transplant in a prepared hole at the same depth that it was growing before. Replace the soil in both pots and moisten lightly again to bond the new soil with the original. If you are careful, a wedge of soil can be removed intact. The root system will not be disturbed and the plant will survive with little or no transplant shock. Do not fertilise a transplant for two weeks.

To prevent possible drop-off and wilting from shock, you may want to use Rootone or Transplantone. These safe powders, available at nurseries, contain root-growth hormones and fungicides. They won't be necessary if you transplant carefully.

Transplanting to Large Pots

Transplanting from smaller to larger pots is a simple procedure. The marijuana root system quickly fills small pots. To transplant, moisten the soil and let it sit to become evenly moist. Pick the potted plant up, and, while holding the base of the stem, rap the pot sharply against something solid. You might cover the soil surface with a piece of newspaper or aluminium foil, which makes the job cleaner. When it is done at the right time, the root system, with all the soil adhering, will pop out of the pot intact.

An approximate time guide for transplanting is shown in Table 17(currently excluded from this guide). At these times, give or take a week, the plants should be root-bound and all the soil will adhere to the roots, making the transplanting clean and easy.

If the root system has not filled the pots by this time, wait a few weeks and the process will be easier. If the root system comes out in a small ball and much of the soil is empty of roots, then soil conditions are poor (usually poor drainage and over-watering) or you are transplanting much too seen.

If the root system doesn't easily pop out, run a knife around the sides of the pot. Sometimes the roots stick to the sides, particularly is paper and clay containers. Check to see if the drainage holes are plugged. Plugged holes stop air from displacing the soil, and the vacuum pressure prevents the soil from sliding out of the pot.

Table 17
Guide for Transplanting

Transplant	During
Six-ounce cups	Second to third week
Four-inch pots	Third to fourth week
Six-inch pots (half gallon)	Fourth to fifth week
Eight-inch pots (one gallon)	Seventh to eighth week
Two-gallon containers	About the tenth week

Transplant into a soil mixture that is the same as (or is very like) the one in the original pots. Otherwise, the soils may have different osmotic properties, and the water may not disperse evenly. (This doesn't apply to small pots that are used for germination and are filled with vermiculture, Jiffy Mix, or other mediums.) Don't bury the stem. Keep the stem base at the same depth that it was growing. {Figure 47. Transplant when the plant is root-bound.}

Transplanting in Plastic Bags

To transplant plants that are in plastic bags, place the old bag into the larger-size bag. Put some soil mixture underneath, to bring the base of the stem to where the new soil surface will be. Cut the old plastic bag away and fill the side spaces with soil mixture. Two people make the job easier.

8.4 Supports for Plants

Under natural conditions, stems undergo stress from wind, rain, and animals. These stresses, which indoor plants do not ordinarily face, strengthen the stem. Indoor stems grow sturdy enough to support their own weight and not much more. Plant energy is used to produce more light-gathering leaf tissue, rather than wind-resistant stem tissue. Stems remain slender, usually about one-half to three-quarter inches at maturity. Since you are growing the plants for their leaves and flowers, this does not present a problem.

Healthy plants do not ordinarily need support. If many of your plants have weak or spindly stems, there is a deficiency in either light or nutrients (notably potassium). Simply not having enough light will cause the plants to elongate, with sparse foliage and weak growth. Too much red light will cause elongation, too, so make sure you include a strong blue light, if you are using incandescents or floodlights.

Hanging the lights higher than the recommended distances will cause the plants to elongate by rapidly growing up to the lights. Unlike sunlight, the intensity of artificial light diminishes dramatically with the distance from the lights. The plants respond by growing toward the light, seeking the higher intensity.

Under artificial light, some plants may need support during the seedling stage or because of accident. Depending on plant size, use straws, pencils, dowels, or standard plant stakes such as cane sticks. Set them in the soil and affix the stem with string, masking tape, or wire twists such as those that come with plastic trash bags. Do not tie string or wire tightly around the stem; make a loose loop. The stem will grow in girth and can be injured by a tight loop.

Probably the simplest method of support is to take a rigid piece of wire, form a "C" at one end and bend it to a right angle to the stem. Set the straight end in the soil and place the stem inside the "C." Pipe cleaners are ideal for seedlings. With larger plants, straighten a coat hanger and use the same method.

A common practice in greenhouses where tree seedlings are raised is to shake each plant once or twice daily. This practice simulates natural vibrations from the wind, and the plant reacts by increasing the growth around the stem. The stem grows thicker and stronger, and the tree can better fend once it is transplanted. It works the same way with marijuana. A fan blowing on the plants will also work. These practices are useful if you plan to move your plants outdoors. Otherwise, healthy indoor plants that will remain indoors need no special stem strengthening.

8.5 Uniform Growth

The light intensity from artificial lights drops dramatically as the distance from the light source increases. When the plants are not of equal height, the shorter ones receive less light and consequently grow slower than the taller ones. This compounds the situation and, left to themselves, the shorter plants will stop growing and eventually die from lack of light.

It is important to keep all of the plants close to the lights. {Figure 48. Hang the fixture at an angle corresponding to that of the tops of the plants.} This encourages stocky, full growth and can make the difference between harvesting stems and harvesting smoking material.

One way to deal with uneven height is to line the plants up to the line of the plant tops. As the plants grow, move them to different spots in the garden to accommodate their different sizes. Or raise the shorter plants up to the lights by placing them on milk crates, tin cans, bricks, etc.

The quality and quantity of light emitted by a fluorescent is strongest in the middle and weaker toward the ends of the tube. Female plants require more light than males. Once the genders of the plants become clear, move the males to the ends of the system, thus leaving the stronger middle light for the females.

8.6 Pruning

Probably the easiest way to deal with uneven growth is to cut back the taller plants to the average height. You may find this emotionally difficult, but pruning will not harm the plant. Cutting off the growing shoot forces the plant to develop its branches. Some growers cut back all of their plants when they are three to

four weeks old. Any horizontal space is quickly filled with growing branches and the plants grow full and robust.

The growing shoots are the most potent plant parts until the flowers appear. Generally, the potency increases with growth. By three months' age, most shoots will be high-quality smoke. You can cut shoots at any time; just don't overdo it. Give the plant a chance to grow and fill out to a good size. Severe pruning will slow growth. New growth may be distorted and abnormal, with a drop in potency.

Each time you cat a growing shoot, whether it is the stem tip or a branch tip, two shoots being to grow from the nearest leaf axils. However, don't think that cutting all the growing shoots of a plant twenty times over the course of a season will yield a plant bearing over a million new shoots, or even that the plants will double their size if pruned. Pruning simply allows the plant to develop its branches earlier. The branches present more area to gather light and, hance, can grow to fill a larger space. However, the plant's size is basically determined by the seed's potential within the limitations of the environment.

Cutting the growing shoots or removing some leaves does not harm the plants. Plants are well adapted to the loss of parts to predators, wind, etc., in the natural world. When leaves are damaged or lost, the plant plugs the wound. The leaf isn't replaced or repaired, but new leaves are continually being formed from the growing shoots. The stem, since it connects all parts of the plant, is more important to the plant as a whole. When the stem breaks or creases, it is capable of repair. You can help the plant repair its stem by splinting the wound or somehow propping the stem up straight. Stems take about four or five days to heal.

When you cut the stem or leaves, you may see the plant's sap momentarily spurt before the wound is plugged. The sap contains primarily the products of photosynthesis, in the form of sucrose (table sugar). Smaller amounts of materials associated with the living organism such as minerals, amino acids, and enzymes are also present. In marijuana, the sap is usually colourless, although a bright red colour - it looks like blood - is not uncommon in later life. The red colour is due to haematin compounds and anthocyanin pigments that naturally build up in some varieties. The red colour may also indicate a nutrient deficiency, notably of nitrogen, phosphorus, potassium, or magnesium.

8.7 Training

Plants grow from the tips of their stems and branches. The growing tip (apical meristem) of the plant contains a hormone that acts as a growth inhibitor. This prevents the branches (lateral buds) from growing. The further a branch is from the growing tip, the less effect of the inhibitor. This is why some species of plants form a cone or Christmas-tree shape with the longest branches toward the bottom of the stem. This is also why the branches grow from the top of the plant when the tip is removed. Once the growing tip is removed, the next highest growing shoot(s) becomes the source of the inhibitor. Under artificial light, the bottom branches may not receive enough light to grow even though they are far away from the inhibitor. Usually the longest branches are toward the middle of the plant.

Some growers hate to cut the growing shoots on the main stem, since it forms the largest and most potent buds by harvest. But you can neutralise the effects of the inhibitor, without cutting the growing shoot, by bending the tip. This allows you to control the height of the plants, and forces them to branch. The top two to six inches of the stem are flexible. Bend it in an arc and secure it to the stem with a wire twist or string. Remove the wire twist in a few days so that the growing tip does not break itself as it twists up to the light. Don't bend the stem too far down. Keep it in the strong light or else it will stop growing. If you accidentally break the tip, you can splint it with matchsticks or ice-cream sticks secured with wire twists or tape until it heals. {Figure 49. The flexible tip is held in place with a wire twist.}

To develop large, full plants with well-developed branches, secure the growing tip once or twice for a few days while the plants are young (one to three months).

It is possible to train the tip so that the stem will form a series of "S" shapes or even circles. During flowering, train the tips so that they grow horizontally. This method encourages thick, dense growth. The branch tips can also be trained. Keep bending any tips that grow above the others. This creates a garden

filled with a cubic layer of vigorous flower clusters rather than a lot of stems.

We want to emphasise that when you get the knack of training the tips, you can more than double the yield of the most potent plant parts. {Figure 50. Stem trained in an "S" shape.} {Figure 51. Tops trained horizontally during flowering.}

Chapter Nine
NUTRIENTS AND FERTILISING

9.2 Nutrients

There are about 15 elements known to be essential to plant life. Carbon, hydrogen, and oxygen are absorbed from air and water. The remaining 12 elements are absorbed primarily from the soil, in mineral (inorganic) forms such as NO3- and K+. They constitute a natural part of soil that becomes available to the plant os organic matter decays and soil particles such as sand and clay dissolve.

Soil elements that are necessary for normal growth are called nutrients. The elements nitrogen (N), phosphorous (P), and potassium (K) are considered major nutrients. The three numbers that appear on all fertiliser packages give the available percentage of these three nutrients that the fertiliser contains; and always in the order N-P-K. For example, 10-2-0 means 10 percent N, 2 percent P (actually, 2 percent P2O5), and no K (actually, no K2O). Fertility is often measured by the amounts of major nutrients a soil contains. Relatively large amount of N-P=K are needed for lush growth.

Three other elements - calcium (Ca), sulphur (S), and magnesium (Mg) - are called secondary nutrients. Plants require less of these nutrients, and most cultivable soils contain adequate amounts for good growth.

Six remaining elements are called trace elements or micronutrients. As their name implies, they are needed in very small amounts. Commercial soils contain enough trace elements to sustain normal growth. The trace elements are also present in manures, humus, ash, and limestone.

Nitrogen

The amount of nitrogen a soil can supply is the best indication of its fertility. Nitrogen, more than any other soil nutrient, is inextricably linked with the living ecosystem. Nitrogen is continually cycled through living systems: from soil to plants and back to the soil, primarily by the activity of soil microorganisms. Nitrogen is essential to all life. Nitrogen is a key element in the structure of amino acids, the molecules which make up proteins. These, and all other biomolecules, are synthesised by the plant. Chlorophyll, genetic material (for example, DNA), and numerous enzymes and plant hormones contain nitrogen. Hence, N is necessary for many of the plant's life processes.

Cannabis is a nitrophile, a lover of nitrogen. Given ample N, Cannabis will outgrow practically and plant. Ample nitrogen is associated with fast, lush growth, and the plant requires a steady supply of nitrogen throughout its life. Marijuana's requirements for N are highest during the vegetative growth stages.

Phosphorous

P is a constituent of energy-transfer compounds such as NADP and ATP, and molecular complexes such as the genes. The energy compounds are necessary for photosynthesis, respiration, and synthesis of biomolecules. Cannabis takes up large amounts of P during germination and seedling stages. During flowering and seed set, Cannabis' need for phosphorous is also high.

Potassium

K influences many plant processes, including photosynthesis and respiration, protein synthesis, and the

uptake of nutrients. Just as with P, K uptake is highest during the earliest growth stages. K is associated with sturdy stems and resistance to disease in plants.

Calcium

Ca functions as a coenzyme in the synthesis of fatty compounds and cell membranes, and is necessary for normal mitosis (replication of cells). Plants take up much more Ca than the small amount necessary for normal growth. Ca is not added to soil as a nutrient; is added to adjust the soil's chemistry or pH.

Sulfur

S is a constituent of certain amino acids and proteins. It is an important part of plant vitamins, such as biotin and thiamine, which are necessary for normal respiration and metabolism. (Plants synthesise all vitamins they need.) Most soils suitable for growing marijuana contain plenty of S.

Magnesium

Mg is involved in protein synthesis and metabolism of carbohydrates. Mg is the central element in the structure of chlorophyll molecules and hence has an important role in photosynthesis. Most mineral soils and commercial soils have a good supply of Mg.

Trace Elements

The trace elements (Fe, Mn, Mb, B, Cu, Zn) are particularly important in the coenzymes and catalysts of the plant's biochemistry. Many life processes, particularly the synthesis and degradation of molecules, energy transfer, and transport of compounds within the plant, depend on trace elements. Trace elements are not used in large quantities to spur growth, but are necessary in minute amounts for normal growth. Indoor soils rarely require an addition of trace elements.

All the nutrients are needed for normal growth. However, most of them are supplied by the potting soil. Ca, S, and the trace elements rarely present any problems. For most growers, fertilising will simply require periodic watering with a complete fertiliser, one that contains N, P, and K.

9.3 Application: Fertilising

To grow to a large size, marijuana requires a steady supply of nutrients. These can be added to the soil before planting or anytime during growth. Bulk fertilisers are added while the soil is mixed, as described in section 6. These include manures, composts, humus, and concentrated fertilisers, such as rose food. Once the plants are growing, never condition or mulch indoor soils with bulk fertilisers. they promote moulds and fungi and attract other pests to the garden. Concentrated fertilisers can damage the plants if they come in direct contact with the stem or roots.

While the plants are growing, nutrients are given in solution; they are dissolved in water, and the plants are watered as usual. Soluble fertilisers can be either organic or inorganic (chemical), and come in a wide range of concentrations and proportions of nutrients. Two organic fertilisers are liquid manure (about 1.5-1.0-1.5) and fish emulsion ((Some fish emulsion may contain whale by-products.)) (about 5-1-1). Chemical fertilisers commonly may have 20-20-20 or 5-10-5, or may contain only one nutrient, such as 16-0-0.

A 10-5-5 fertiliser is 20 percent soluble nutrients and 80 percent inert ingredients. a 30-10-10 has 50 percent available nutrients and 50 percent inert ingredients. There is approximately the same amount of N in one tsp. of 30-10-10 as in three tsps. of 10-5-5.

Actually, you can almost use any fertiliser, but the nitrogen content should be proportionately high, and there should be some P and L also present. For example, a 20-20-20 would work fine, as would a 12-6-6 or a 3-4-3, but not a 2-10-10 or a 5-10-0.

How much fertiliser to use and how often to fertilise depend primarily on the fertility of the soil and the size

of the container relative to the size of the plant. Small plants in large pots usually do not need to be fertilised. Even in small pots, most plants do not need to be fertilised for at least the first month.

As the plants grow, they take nutrients from the soil, and these must be replaced to maintain vigorous growth. During the vegetative stage, even plants in large pots generally require some fertilising, particularly with N.

The rate of growth of indoor plants is usually limited by the amount of light and space, once adequate nutrients are supplied. At this point, an increase in nutrients will not increase growth. Your goal is to supply the plants with their nutritional needs without overfertilising and thus toxifying the soil.

Most fertilisers are designed for home use and have instructions for fertilising houseplants. Marijuana is not a houseplant, and it requires more nutrients than houseplants. The extra nutrients that it needs may be supplied by the use of large pots and a fertile soil mixture. In many cases, you will need to fertilise only in the dosages recommended on fertiliser packages for houseplants. For instance, Rapid-Gro (23-19-17) is popular among marijuana growers; use one tablespoon per gallon of water every two weeks.

A typical program for fertilising might be to fertilise during the fifth week of growth and every two weeks thereafter until flowering. Then discontinue fertilising (or give at one-half concentration) unless the plants show a definite need for nutrients. It is better to fertilise with a more diluted solution more often than to give concentrated doses at longer intervals. (For instance, if instructions call for one tablespoon of fertiliser per gallon once a month, use one-quarter tablespoon per gallon once a week.)

Make sure that a fertiliser is completely dissolved in the water before you apply it. Put the recommended amount of fertiliser in a clear glass bottle and mix with about one cup of water. Shake vigorously and then allow it to settle. If any particles of fertiliser are not dissolved, shake again before adding the rest of the water. If you have difficulty getting all the fertiliser to dissolve, first add hot top water. If the fertiliser still does not completely dissolve, you should use another fertiliser.

Never fertilise a dry soil or dry Soilless medium. If the medium is dry, first water with about one-half quart of plain water per pot. Let the pots sit for about 15 minutes so that the water is evenly dispersed in the pot. Then fertilise as usual.

It is difficult to give instruction for fertilising that will cover all garden situations. You want to supply the plant with its nutritive needs, but overfertilising con toxify the soil. Fertilising according to instructions for houseplants (both in frequency and concentration) should not toxify the soil. However, the plants may sometimes require more frequent or more concentrated fertilising. A good way to judge the plant's needs is not to fertilise one plant, double the fertiliser of another plant, and give the rest of the plants their normal dose. If the unfertilised plant grows more slowly, or shows symptoms of deficiencies, then probably all the plant are depending on soluble fertilisers and must be fertilised regularly. If the plants receiving the double dose grows faster than the other plants, increase the other plants' supply also. On the other hand, if there is little difference among the plants, then the soil is providing the plants with enough nutrients, and they either should not be fertilised or should be fertilised with a less-concentrated solution.

Because they are grown in a relatively small area, it is easy to overfertilise indoor plants. When plants are vigorous, look healthy, and are growing steadily, don't be anxious to fertilise, particularly if you have already fertilised several times with soluble fertilisers. Slow growth or symptoms of deficiencies clearly indicate the need for fertilising.

Overfertilising

In an effort to do the best for their plants, some people actually do the worst. Overfertilising puts excessive amounts of nutrients in the soil, causing toxic soil conditions. Excessive amounts of one nutrient can interfere with the uptake of another nutrient, or change normal plant-soil relations. Since it takes time for a build-up to occur high concentrations of nutrients generally encourage excellent growth until the toxic level is reached.

It takes less N than other nutrients to toxify the soil; hence there is less margin for error when using N. Too much N changes the osmotic balance between plant and soil. Instead of water being drawn into the plant, water is drawn away and the plant dehydrates. The leaves feel limp even though the plant is well watered. The plant will soon die. This tips of the leaves die first and very rapidly the leaves change colour, usually to gold, but sometimes to a brown or green-grey. This change in the plants is faster, more dramatic, and more serious than for any kind of nutrient deficiency.

You can save the plants by immediately leaching the pots as soon as the condition is recognised. Place the pots outdoors or in a sink or bathtub. Discard the top inch or two of loose dirt. Run lukewarm water through the soil until a gallon of water for each two gallons of soil has passed through each pot. The leaves recover turgor in one or two days if the treatment works.

Foliar Feeding

Foliar feeding ((Nitrogen fertilisers are usually NO3 (nitrate) or NO2 (nitrite), substances which are also used to preserve food. They have been shown to undergo reactions to form carcinogenic substances (nitrosamines). As with eating food treated with nitrates and nitrites (hot dogs, sandwich meats, etc.), there is a possibility that such substances might be ingested by eating or smoking foliar-fed plants.)) (spraying the leaves with fertiliser) is a good way to give the plants nutrients without building up the amount of soluble substances in the soil. After the first month, foliar feed the plants with, for example, fish emulsion or a chemical fertiliser. Use any fertiliser that states it can be used for foliar feeding even if it says "not recommended for foliar feeding houseplants." Use a fine-mist sprayer, such as a clean Windex or Fantastik bottle. Dilute the fertiliser according to directions (fish emulsion at one tablespoon per gallon) and spray both sides of the leaves. When foliar feeding, you should spray the plants with plain water the next day, to dissolve unabsorbed nutrients and clean the plants.

Foliar spraying is also a good way to treat plants suffering from nutrient deficiencies. Some nutrient deficiencies actually are caused by the soil's chemistry, rather than by the absence of the nutrient in the soil. Addition of the necessary nutrient to the soil may not cure the plants' problem, because the nutrient becomes locked in the soil, or its uptake may be limited by high concentrations of other elements present in the soil. Foliar feeding is direct, and if the plant's deficiency symptoms do not begin to clear up, then the diagnosis is probably incorrect.

9.4 Nutrient Deficiencies

Before Diagnosing

Before you assume the plant has a nutrient deficiency, make sure the problem is not due to other causes. Examine the plant leaves, and along the stem and in the soil.

Even under the best conditions, not all leaves form perfectly or remain perfectly green. Small leaves that grew on the young seedling normally die within a month or two. Under artificial lights, bottom leaves may be shielded from the light, or be too far away from the light to carry on chlorosynthesis. These leaves will gradually turn pale or yellow, and may form brown areas as they die. However, healthy large leaves should remain green at least three to four feet below the plant tops, even on those plants under small light systems. Under low light, the lower-growing shoots as well as the large leaves on the main stem are affected. Some symptoms of nutrient deficiencies begin first at the bottom of the plant, but these symptoms generally affect the lower leaves on the main stem first, and the progress to the leaves on the branches.

Although some deficiency symptoms start on the lower, older leaves, others start at the growing shoots or at the top of the plants. This difference depends on whether or not the nutrient is mobile and can move from the older leaves to the active growing shoot. Deficiency symptoms of mobile nutrients start at the bottom of the plant. Conversely, deficiency symptoms of immobile nutrients first appear on the younger leaves or growing shoots at the top of the plant. N, P, K, Mg, B, and Mb are mobile in the plant. Mn and Zn are less mobile, and Ca, S, Fe, and Cu are generally immobile.

A dry atmosphere or wet soil may cause the blade tips to turn brown. Brown leaf tips also may indicate a nutrient deficiency, but in this case, more tissue will turn brown than just the end tips.

Chlorosis and necrosis are two terms which describe symptoms of disease in plants. Chlorosis means lacking green (chlorophyll). Chlorotic leaves are pale green to yellow or white. Chlorotic leaves often show some recovery after the necessary nutrient is supplied. Necrosis means that the tissue is dead. Dead tissue can be gold, rust, brown, or grey. It is dry and crumbles when squeezed. Necrotic tissue cannot recover.

Symptoms of deficiencies of either N, P, or K have the following in common: all involve some yellowing and necrosis of the lower leaves, and all are accompanied by red/purple colour in stems and petioles. The simplest way to remedy these deficiencies is to fertilise with a complete fertiliser containing nearly equal proportions of three nutrients.

Nitrogen

N is the most common deficiency of Cannabis indoors or out. Nitrogen deficiencies may be quite subtle, particularly outdoors, where the soil may continuously provide a small amount of nitrogen. In this case the opt of the plant will appear healthy, and the plant will grow steadily, but at a slow pace. The deficiency becomes more apparent with growth, as more and more of the lower leaves yellow and fall. The first sign is a gradual, uniform yellowing of the large, lower leaves. Once the leaf yellow, necrotic tips and areas form as the leaves dry to a gold or rust colour. In small pots, the whole plant may appear pale (or lime colour) before many bottom leaves are affected to the point that they yellow or die. Symptoms that accompany N deficiency include red stems and petioles, smaller leaves, slow growth, and a smaller, sparse profile. Usually there is a rapid yellowing and loss of the lower leaves that progresses quickly to the top of the plant unless nitrogen is soon added.

Remedy by fertilising with any soluble N fertiliser or with a complete fertiliser that is high in N. If your diagnosis is correct, some recovery should be visible in three or four days. Pale leaves will regain some colour but not increase in size. New growth will be much more vigorous and new stems and petioles will have normal green colour.

Indoors, you should expect plants to need N fertilisation a few times during growth. Once a plant shows N deficiency, you should fertilise regularly to maintain healthy and vigorous growth. Fertilise at about one-half the concentration recommended for Soilless mixtures. Increase the treatment only if the plants show symptoms again. Once the plants are flowering, you may choose not to fertilise if the plants are vigorous. They will have enough N to complete flowering and you don't want to chance toxifying the soil at this late date.

Phosphorous

P deficiency is not common indoors, but may appear outdoors, particularly in dry, alkaline soils or in depleted soils, or during cool weather. Phosphorus deficiency is characterised by slow and sometimes stunted growth. Leaves overall are smaller and dark green; red colour appears in petioles and stems. The leaves may also develop red or purple colour starting on the veins of the underside of the leaf. Generally the tips of most of the leaf blades on the lower portion of the plant die before the leaves lose colour. Lower leaves slowly turn yellow before they die. Remedy with any soluble P-containing fertiliser. Affected leaves do not show much recovery, but the plant should perk up, and the symptoms do not progress.

Potassium

K deficiencies sometimes show on indoor plants even when there is apparently enough supplied for normal growth. Often, potassium-deficient plants are the tallest ((Potassium is associated with apical dominance in some plant species.)) and appear to be the most vigorous. Starting on the large lower leaves, the tips of the blades brown and die. Necrotic areas or spots form on the blades, particularly along the margins. Sometimes the leaves are spattered with chlorotic tissue before necrosis develops, and the leaves look pale or yellow. Symptoms may appear on indoor plants grown in a soil rich in organic

material. This may be due to high salinity (Na) of some manures or composts used in the soil. Red stems and petioles accompany potassium deficiencies. K deficiencies that could seriously affect your crop rarely occur with indoor soils. However, mild symptoms are quite common. Usually the plants grow very well except for some necrotic spotting or areas on the older leaves. (This condition is primarily and aesthetic problem, and you may choose not to fertilise. See 19.3.)

K deficiencies can be treated with any fertiliser that contains potassium. Wood ashes dissolved in water are a handy source of potassium. Recovery is slow. New growth will not have the red colour, and leaves will stop spotting after a couple of weeks. In a K-deficient soil, much of the added potassium is absorbed by the soil until a chemical balance is reached. Then additional potassium becomes readily available to the plant.

Calcium

Ca deficiencies are rare and do not occur if you have added any lime compound or wood ash. But calcium is added primarily to regulate soil chemistry and pH. Make sure that you add lime to soil mixtures when adding manures, cottonseed meal, or other acidic bulk fertilisers. An excess of acidic soil additives may create magnesium or iron deficiencies, or very slow, stunted growth. Remedy by adding one teaspoon of dolomitic lime per quart of water until the plants show marked improvement. Periodically fertilise with a complete fertiliser. Foliar feeding is most beneficial until the soil's chemistry reaches a new balance.

Sulfur

S is plentiful in both organic and mineral soils. Liming and good aeration increases S availability. Hence S deficiencies should not occur in soils that are suitable for growing marijuana. However, sulfur deficiencies sometimes can be confused with N deficiencies and may also occur because of an excess of other nutrients in the soil solution. Sulfur-deficiency symptoms usually start at the top of the plant. There is a general yellowing of the new leaves. In pots, the whole plant may lose some green colour. Both sulfur and Mg deficiencies can be treated with the same compound, epsom salts ($MgSO_4$). Epsom salts, or bathing salts are inexpensive and available at drug stores.

Magnesium

Mg deficiencies are fairly common. They frequently occur in Soilless mixtures, since many otherwise all-purpose fertilisers do not contain Mg. Magnesium deficiencies also occur in mixtures that contain very large amounts of Ca or Cl. Symptoms of Mg deficiency occur first on the lower leaves. There is chlorosis of tissue between the veins, which remain green, and starting from the tips the blades die and usually curl upward. Purple colour builds up on stems and petioles.

A plant in a pot may lose much of its colour in a matter of weeks. You may first notice Mg symptoms at the top of the plant. The leaves in the growing shoot are lime-coloured. In extreme cases, all the leaves turn practically white, with green veins. Iron deficiency looks much the same, but a sure indication of Mg deficiency is that a good portion of the leaf blades die and curl. Treat Mg symptoms with one-half teaspoon of epsom salts to each quart of water, and water as usual. The top leaves recover their green colour within four days, and all but the most damaged should recover gradually. Continue to fertilise with epsom salts as needed until the plants are flowering well. If you are using soilless mixtures, include epsom salts regularly with the complete mixture. Because Mg deficiencies may indicate interference from other nutrients, foliar-spray with Mg to check your diagnosis if the plants are not obviously recovering.

Iron

Fe deficiency rarely occurs with indoor mixtures. Iron is naturally plentiful in most soils, and is most likely to be deficient when the soil is very acid or alkaline. Under these conditions, which sometimes occur in moist eastern soil outdoors, the iron becomes insoluble. Remedies include adjusting the Ph before planting; addition of rusty water; or driving a nail into the stem. Commercial Fe preparations are also available. If the soil is acidic, use chelated iron, which is available to the plants under acidic conditions.

Symptoms of iron deficiency are usually distinct. Symptoms appear first on the new growing shoots. The leaves are chlorotic between the veins, which remain dark green and stand out as a green network. To distinguish between Mg and Fe deficiencies, check the lower leaves for symptoms. Iron symptoms are usually most prominent on the growing shoots. Mg deficiencies will also show in the lower leaves. If many of the lower leaves have been spotting or dying, the deficiency is probably Mg. Mg deficiencies are much more common than iron deficiencies in marijuana.

Other Trace Elements

The following deficiencies are quite rare. Trace elements are needed in extremely small amounts, and often enough of them are present as impurities in fertilisers and water to allow normal growth. Many houseplant fertilisers contain trace elements. Trace-element deficiencies are more often caused by an extreme pH than by inadequate quantities in the soil. If a deficiency is suspected, foliar-spray with the trace element to remedy deficiencies. Our experience has been that trace-element deficiencies rarely occur indoors. We advise you not to add trace elements to indoor soils, which usually contain large amounts of trace elements already because of the addition of organic matter and liming compounds. It is easy to create toxic conditions by adding trace elements. Manufacturers also recommend using amounts of trace elements that may be too high for indoor gardens; so use them at about one-fourth of the manufacturer's recommended dose if an addition is found to be necessary.

Manganese

Mn deficiency appears as chlorotic and the necrotic spots of leaf tissue between the veins. They generally appear on the younger leaves, although spots may appear over the whole plant. Manganese deficiencies are not common. Manganese is present in many all-purpose fertilisers. Mn deficiencies may occur if large amounts of Mg are present.

Boron

B deficiency may occasionally occur in outdoor soils. The symptoms appear first at the growing shoots, which die and turn brown or grey. The shoots may appear "burned," and if the condition occurs indoors, you might think the lights have burned the plant. A sure sign of boron deficiency is that, once the growing tip dies, the lateral buds will start to grow but will also die. B deficiency can be corrected by application of boric acid, which is sold as an eyewash in any drugstore. Use one-fourth teaspoon per quart of water. Recovery occurs in a few days with healthy growth of new shoots.

Molybdenum

Mb deficiency occurs in outdoor soils, but rarely indoors. Mb is readily available at neutral or alkaline pH. Mb is essential for nitrogen metabolism in the plant, and symptoms can be masked for a while when N fertilisers are being used. Usually there is a yellowing of the leaves at the middle of the plant. Fertilising with nitrogen may remedy some of the yellowing. However, Mb symptoms generally progress to the growing shoots and new leaves often are distorted or twisted. Mb is included in many all-purpose fertilisers.

Zinc

Zn-deficiency symptoms include chlorosis of leaf tissue between the veins. Chlorosis or white areas start at the leaf margins and tips. More definite symptoms are very small, new leaves which may also be twisted or curled radially. Zn deficiencies may occur in alkaline western soils. Galvanised nails can be buried or pushed into the stem. Commercial preparations of zinc are also available.

Copper

Cu deficiencies are rare; be careful not to confuse their symptoms with the symptoms of overfertilisation. The symptoms appear first on the younger leaves, which become necrotic at the tips and margins. Leaves will appear somewhat limp, and in extreme cases the whole plant will wilt. Treat by foliar-spraying

with a commercial fungicide such as CuSO4.

9.5 Soilless Mixtures

Soilless mixtures are an alternative to using large quantities of soil. Their main advantage is complete control over the nutrients that your plants receive. Soilless mixtures are also inexpensive and easy to prepare. They have a near-neutral pH and require no pH adjustment.

Soilless mixtures are made from soil components such as vermiculite, sand, or perlite. Soilless mixtures should be blended in such a way that they hold adequate water, but also drain well and do not become soggy. A good general formula is two parts vermiculite to one part perlite. About 10 percent coarse sand or gravel can be added to give weight and stability to the pots. Instead of vermiculite, you can use Jiffy-Mix, Metro-Mix, Ortho-Mix, Pro-Mix and other commercial soilless mixtures, which are fortified with a small amount of necessary nutrients, including trace elements. You can also substitute coarse sand for perlite.

Potting

It is best to use solid containers with soilless mixtures rather than plastic bags. Grow the plants in one- to three-gallon containers. There won't be much difference in the size of the plants in one-gallon or in three-gallon sizes, but you will have to water a large plant every day in a one-gallon container. (The plants can always by transplanted to a larger container.) The pots must have drainage holes punched in the bottoms. Pot as usual, and add one tablespoon of dolomitic lime or two tablespoons of wood ash to each gallon of mixture.

Germinating

Plants may have problems germinating in soilless mixtures. The top layer of mixture often dries rapidly, and sprouts may die or not germinate. Young seedlings also seem to have difficulty absorbing certain nutrients (notably potassium), even though adequate amounts of nutrients are being added. Since this difficulty may retard growth, it is best to start the plants in small pots with soil. Use eight-ounce paper cups, tin cans, or quart milk containers cut in half. Mix three parts topsoil or potting soil to one part soilless mixture. Fill the starting pots and germinate as usual. When the plants are two to three weeks old, transplant to the soilless mixture. First moisten the soil, and then remove the soil as intact as possible. You might handle the transplant like making castles, by carefully sliding the moist soil out of the pot. Or you can cut away the sides of the container while you place the transplant in the soilless mixture. When watering, make sure you water around the stem to encourage roots to grow into the soilless mixture.

Peat pellets that expand are also good for starting seedling. Plant several seeds in each pellet, and place it in the soilless mixture after the sprouts appear.

Fertilising

Soilless mixtures can be treated with a trace-element solution. We have grown crops with no special addition of trace elements, and the plants completed their lives without showing symptoms of trace-element deficiency. In these cases there were apparently enough trace elements in the lime and the fertilisers that were used to provide the major nutrients. Many all-purpose fertilisers also contain trace elements. However, it is a good idea to treat soilless mixtures with a mild solution of trace elements before planting. Large plants can be treated a second time during the third or fourth month of growth. Do not use trace elements more often unless plants show definite trace-element deficiencies.

Iron is the only trace element that is needed in more than minute quantities. Iron can be supplied by mixing a few brads or nails into the soilless mixture.

Use any soluble fertiliser that is complete, that is, that contains some of each of the major nutrients. Choose one with a formula that is highest in N but contains a good portion of both P and K. For example, Rapid-Gro is 23-19-17 and works well for soilless mixtures.

Table 18 gives a formula that has worked well for us. The figures in it are a guide for estimating the amounts of fertiliser to use. When choosing a fertiliser by means of this chart, use N for a guide. For example, suppose the only fertiliser you can find that has good proportions of the major nutrients as a 20-15-15. Divide 5 (the figure for N in the table) by 20 (the figure for N in the fertiliser), and get the result 1/4. That is, the fertiliser if four times as concentrated in N as you need; so you would use one-fourth the amount of fertiliser shown in Table 18. For instance, during the vegetative stage, you would give the plants one-half to three-fourths of a level teaspoon of fertiliser per gallon of water each time you water.

Table 18 - Guidelines for Fertilizing Soilless Mixtures

Growth Stage	N	P2O5	K20	Amount
Seedling	5	3	4	1.5 to 2 tsp/gal
Vegetative	5	2	3	2 to 3 tsp/gal
Flowering	5	5	3	0.5 tp 1.5 tsp/gal

It is also not necessary to fertilise in these ratios. You could use a 10-10-10 fertiliser throughout growth; you would use half the amounts listed in Table 18. The most important point is that the plant receive enough of each element, not that they receive specific proportions.

Fertilising according to volume of fertiliser is not very accurate, and also does not take into account other variables (such as variety, light, temperature, etc.) that determine the amounts of nutrients your plants can use. However, it is a simple and useful way of estimating the plant's needs. You can more accurately gauge the plants' needs by giving a sample plant twice the concentration of fertiliser, and another half the concentration. Their performance will give you an idea of whether you are using too much or too little fertiliser. Too much fertiliser is the most damaging condition; so when in doubt give the plants less rather then more. Do not continue to give the plants the recommended amounts of fertiliser if the sample plant that is receiving less nutrients is growing as well as the other plants.

Another way of monitoring the plant's growth is to grow a few plants in a standard soil mixture. This will show you whether the plants in the soilless mixture are growing as fast as they should, and will give you a reference for diagnosing deficiencies.

Besides providing N, P, K, and the trace elements, you must also give your plants secondary nutrients. Ca is added by mixing a tablespoon of lime or two tablespoons of wood ash when preparing the soilless mixture. (Calcium is usually present in water and in many fertilisers as part of the salts that contain nutrients, for example, Ca(NO3)2.) Magnesium and sulfur are both found in common epsom salts, MgSO4. Use one-eighth teaspoon of epsom salts to each teaspoon of 5 percent N. For example, if you are using a 20 percent N fertiliser, you would use half a teaspoon of MgSO4 to each teaspoon of fertiliser. (Actually, enough sulfur is often present, either as part of the soilless mixture or as part of nutrient salts to allow growth.) Magnesium can also be supplied by using dolomitic limestone.

Soilless mixtures are something between soil mixtures and water cultures (hydroponics). With hydroponics, the plants are grown in a tank of water. The fertilisers are added in solution, and the water solution is periodically circulated by a pump.

Another variation on soilless mixtures is to add a small amount of soil or humus to the soilless mixture. Some examples are:

1. 4 parts soilless mixture to 1 part soil;
2. 8 parts soilless mixture to 1 part humus;
3. 15 parts soilless mixture to 1 part limed manure.

Overfertilising is less a problem with soilless mixtures then with soil, because of higher concentrations of salts are tolerable in soilless mixtures and because excess salts are easily flushed out of the mixture. A good idea is to flush each pot once after two months of growth, again after four months. Any time the

plants show symptoms of overfertilisation, leach the pots immediately. Flood each pot with plain water so that it runs out the drainage holes. Continue flooding the pots until a couple of gallons of water have run through the pot. Don't fertilise for at least a week. Then fertilise with a more dilute solution that was used before. {Figure 51a. Over fertilisation. Leaves turn bright gold and die, starting at the top of the plant.}

Chapter Ten
DISEASES AND PLANT PESTS

Plants are considered diseased when their health or development is impaired enough that the adverse effects become visible to the eye. Disease may be caused by infectious microbes, such as bacteria or viruses, by pests such as insects, or by nutritional deficiencies or imbalances. However, for diseases that might affect your plants, there should be no need for a plant doctor. You'll be able to diagnose the symptoms after careful observation.

Leaves naturally drop from plants during the course of their lives. Not every leaf will develop perfectly or so. The small leaves that are formed during the first few weeks of growth normally die within three months. Leaves at the bottom of healthy plants often die because they are shielded by the upper instance, in a garden receiving only 80 watts of fluorescent light, the plants may stay green only up to three or four feet away from the lights. Lower leaves may turn pale and yellow and then dry to gold or rust colours.

10.2 Microbial Diseases

Because Cannabis is not native to the Americas, most of the microbial diseases that attack the plant are not found in this country. Homegrown Cannabis is remarkably free of diseases caused by microbes, and there is little chance of your plants suffering from these diseases. Fungal stem and root rots seem to be the only ones of consequence. These occur only because of improper care. Watering too often, coupled with a stagnant, humid atmosphere, encourages stem rot to develop. Stem rot appears as a brown or black discolouration at the base of the stem and is soft or mushy to the touch. Allow the soil to dry between waterings, and be sure to water around the stem, not on it. Wipe as much of the fungus and soft tissue away as possibly. If the rot doesn't disappear in a few weeks, treat it with a fungicide.

10.3 Nutrient Diseases

Diseases due to nutrient deficiencies (see section 9), are common indoors, and their symptoms usually worsen with time, affecting more and more of the plant. Whole leaves may be pale, or turn yellow or white; the condition may first afflict the bottom, or top, or the entire plant at once. Deficiency symptoms often appear as spots, splotches, or areas or chlorotic (lacking green) tissue. Sometimes necrotic (dead) tissue appears that is copper, brown, or gray. However, before you search to section 9, carefully inspect the plants for any signs of plant pests.

10.4 Plant Pests

The indoor garden is an artificial habitat where the plants live in isolation from the natural world. For this reason, few of you will have any problems with plant pests. However, indoor plants are particularly susceptible to pests once contaminated. In nature, the pest populations are kept in check by their natural enemies, as well as by wind, rain, and changing temperatures. Without these natural checks, pests can run rampant through the indoor garden.

The most common and destructive pests are spider mites and whiteflies. Spider mites are barely visible to the naked eye; they are ovoid-shaped. Juvenile mites are transparent and change to green as they suck the plant's tissue. Adults are tan, black, or semitransparent. False spider mites are bright red. Mites are usually well-established before you discover them, because they are so difficult to see.

Whiteflies are white (obviously) but look like tiny moths rather than flies. The adults are about 1/16 inch long, and you may not see one unless if flutters by the corner of your eye. Then shake the plants. If the

result looks like a small snowstorm, the plants are infested with whiteflies. {Figure 52. Left: Spider mite (x16). Right: A match head dwarfs tiny spider mites.}

The symptoms of infection by mites and whiteflies are similar. Symptoms usually appear on the lower leaves and gradually spread to the top of the plant. The first indications are that the plant loses vigour; lower leaves droop and may look pale. Look closely at the upper surfaces of the leaves for a white speckling against the green background. The speckles are due to the pests sucking the plant's chlorophyll-rich tissue. With time, the leaf loses all colour and dies.

Pests are easiest to find on the leaves that are beginning to show some damage. You can usually see mites and whitefly larvae as tiny dots looking up at the lights through the undersides of the leaves.

To find out which pest you have, remove some damaged leaves and inspect the undersides under bright daylight. With spider mites, if you discover them early, a leaf may show only one or two tiny dots (adults) and a sprinkling of white powder (eggs) along the veins. In advanced cases, the undersides look dusty with the spider mites' webbing, or there may be webbing at the leaf nodes or where the leaflets meet the petioles. With whiteflies, you usually see the adults first. On the undersides of the leaves the whitefly larvae look like mites, but there is no webbing, and there are tiny golden droplets of "honeydew" excreted by the adult whiteflies. {Figure 53. Mites appear as black specks when you look up to the lights from the undersides of the leaves. Also see Plate 14.}

Take quick action once you discover plant pests. If the plants are less than a month old, you will probably be better off to clean out the garden, in order to eliminate the source of the pests, and start over. As long as the plants are healthy they can withstand most attacks. The more mature the plants are, the less they are affected by pests. Whiteflies and mites sometimes disappear from flowering plants, particularly the female flowers. Mites are difficult to eliminate completely. Often a holding action will save a good crop.

If only a few plants in your garden are infected, remove them. Or else, remove any leaves that show damage. If the plants are three or more months old, you might consider forcing them to flower while they are still healthy. Plants that are good-sized and still vigorous will usually stand up well to mites once they are flowering.

If you don't want to use insecticides, there are several alternative ways to keep the pests in check until flowering. Mix 1/8 to 1/4 pound of pure soap (such as Ivory flakes) thoroughly in one gallon of lukewarm water. Then cover each pot with foil or newspaper, invert it, and dip and swish the plant around several times in the soapy solution. Let is drip dry and rinse with clear water. Use the dunking procedure every week or two until the plants are larger. This is often enough to get the plants growing well and into flowering before the pest population can become a serious problem.

Two homemade sprays that can be effective are dormant oil sprays ((See "Insects and Pests" in the Outdoor Section.)) and hot pepper sprays.

To make hot pepper spray, mix four hot peppers with one medium onion and on clove garlic (213). Grind or chop and mash them along with some water. Cover the mash with water and allow it so stand a day or two. Add enough water to make two quarts. Strain through a coffee filter or paper towels in a funnel. Add one-half teaspoon of detergent and spray as you would an insecticide.

No one wants to use insecticides; yet they seem to be the only way to eliminate mites. There are a number of insecticides on the market that are relatively safe. Insecticides such as pyrethrum, rotenon, and malathion are relatively non-toxic to warm-blooded animals when used as directed. These are effective against many different plant pests besides mites and whiteflies. Additionally, they break down into harmless compounds such as carbon dioxide and water in a matter of days; so they do not persist in the environment.

Safe insecticides are used for vegetables. Follow all the package precautions. Do not use more, or more often, than recommended. Overuse can kill the plant. The label will list the number of days to wait before you can safely ingest the plant, usually from two to 35 days after spraying.

Both mites and whiteflies generally complete their brief life cycles in about one to two weeks. Because sprays are not effective against the eggs, repeat the spraying about once a week for three successive weeks to completely eliminate the pests. Since their generations are short-lived, some pests may become resistant to the spray. This can be a problem with whiteflies. Try a different insecticide if the first one does not seem to be working.

Add a couple of drops of liquid detergent to each quart of insecticide solution. Detergent acts as a wetting agent and helps the insecticide to contact the pests and stick to the plant. Small plants can be dunked directly in the solution, the surest way to kill pests.

To spray the plants, start at the back of the garden so that you are working away from the plants already sprayed. Spray the entire plant and soil surfaces, paying special attention to the undersides of the leaves where pests tent to congregate. Stay out of the garden and keep the room closed that day.

Sulfur dusts can also be effective against mites and many other pests, and are safe to use. The easiest way to apply them is with a plastic "squeeze" bottle which has a tapered top. Make sure you dust the underside of the leaves.

Before using any insecticide, remove all damaged leaves. Do not use any insecticide during flowering. Rinse the plant with a clear water spray about one week after applying any insecticide, and once more before you harvest. Otherwise there may be residues left which will affect the taste of the grass.

There are several other pests that can be a problem, although they rarely seriously affect marijuana. Aphids are about 1/16 inch long and are black, green, red, or pink. They have roundish bodies with long legs and antennae. Some species have wings. They congregate on the undersides of leaves which may then lose colour and become curled or distorted. Aphids excrete honey-dew droplets on the undersides of the leaves which can attract ants. If ants are also present, set out ant traps, because the ants will spread the aphids to other plants. A few successive washings in soapy water or one or two sprayings of the insecticides mentioned above should eliminate aphids.

Mealy bugs are white, about 3/16 of an inch long, and look like small, flat sowbugs. They don't seem to like marijuana and avoid it of other plants are present. Mealy bugs can be removed individually with cotton swabs and alcohol.

Gnats are attracted to moist soil that is rich in partially decayed organic matter such as manures. To discourage gnats when using manures, cover the top few inches in the pot with the soil mixture and no manure. Drench the soil with malathion solution for gnats or any other soil pest. Flypaper will also help against gnats as well as whiteflies.

Some people don't mind having a few pests on their plants. Whether you want to eliminate the pests completely or simply keep them in check may come down to whether you mind hearing the snap, crackle, and poop as their little bug bodies heat and explode when the harvest is smoked. Commercial marijuana, or any marijuana grown outdoors, will contain innumerable bugs and other small lifeforms.

Prevention

Whiteflies and spider mites are extremely contagious. Mites can be carried to the plant on hands, clothing, or an animal's fur. Many houseplant pests can fly or float to the garden through open windows. Mites crawl through cracks in walls and foundations during autumn, seeking warmth.

Many houseplants are popular because they can withstand abuse and infections by common plant pests. Your houseplants may harbor mites for years without your knowledge. You can find out if your houseplants have mites by placing some marijuana seedlings among the houseplants. Mites seem to enjoy young marijuana plants so much that the plants show symptoms of mites in a matter of weeks of any are nearby.

Hopefully, you'll never have to deal with pests. Prevention is the best policy. Use soil that has been

pasteurised or sterilised to avoid bringing pest eggs and larvae into the garden. Keep the garden isolated from other plants. Use separate tools for the marijuana garden and for other plants. Screen windows in the garden with wire screen or mesh fabrics such as nylon.

Chapter 11
MAINTENANCE AND RESTARTING

To start a new crop, it is best to begin with a fresh soil. This is especially true if the plants were in small pots or were root-bound.

If you have fertilised regularly, the soil may contain near-toxic amounts of salts. Most of the salts build up in the top two-inch layer of soil. To salvage large quantities of soil, discard the top three-inch layer of soil from each pot. Add fresh soil and bulk fertilisers. Thoroughly mix and repot in clean containers.

It is generally not advisable to use the same soil for more than two crops. Although the used soil may not support healthy growth for potted plants, it is an excellent addition to any garden soil. Spread the soil as you would a mulch. The salt concentration is quickly diluted and benefits, rather than harms, garden soil.

Periodically clean the tubes and reflectors to remove dust and grime. As with windows, this dirt substantially decreases the amount of light the plants receive. Fluorescents lose approximately 20 to 40 percent of their original output within a year's use. Generally the higher-wattage tubes decline more rapidly than standard-output tubes. Vita-lite tubes last the longest, followed by standard fluorescents. Gro-tubes are the shortest-lived, and most growers replace them after two crops. Older tubes can be used to start seedlings and during the first month of growth. Since the plants are small and the light system is low, the old tubes generate enough light for healthy growth. Replace incandescent bulbs after 500 light hours.

PART 3: OUTDOOR

CULTIVATION

Chapter 12
CHOOSING A SITE

There are several factors to consider when deciding where to plant, including sunlight, microclimate, availability of water, and condition of the soil. But the garden's security should be your first consideration. No matter what size your garden, rip-offs and confiscation are constant threats. But these risks can be minimised by careful planning and common senses.

In some countries, law-enforcement agencies take a tolerant attitude toward small gardens, and people grow Cannabis in their backyards. In other areas, police are not as enlightened and place an emphasis on cultivation busts. In either case, the larger the garden, the greater the potential danger. {Figure 55. A Nassau Country police officer stands in a field of marijuana plants in Lattingtown, Long Island.}

In Hawaii and California, where marijuana growing has become a booming business, helicopters have been a problem for commercial growers. Aircraft outfitted with visual or infrared equipment, dogs, and finks have all been used to seek out illicit plots. Aircraft equipment is least effective on steep slopes and where the vegetation is lush and varied. Where aircraft are a problem, growers prune marijuana to obscure its distinctive shape. The plants are difficult to detect from a distance when intercropped with bamboo, sunflowers, sugar cane, soybeans, or tall weeds (see Figure 60). Commercial growers often

plant several small dispersed stands or many single plants, which are more difficult to detect and serve as insurance against total loss.

But rip-offs rather than the law are more of a problem for marijuana growers. From every section of the United States, reports confirm that marijuana theft has reached epidemic proportions, and even well-hidden plant fall prey to unscrupulous people. These lowlifes often search near hippie communities and popular planting areas. Their best ally is a loose lip; so keep your garden on a "need to know" basis.

12.2 Where to Grow

Given the value of marijuana, many people think they'll grow an acre or two. But it is much harder to find spots suitable for large-scale farming than to find small garden plots. Large gardens require more planning and commitment, and usually a remote area. They may need a lot more time, energy, and investment in materials and labor-saving machinery than smaller gardens.

A small but well-cultivated garden, say, ten by ten feet, can yield over four pounds of grass each crop. By planning realistically, you'll harvest a good stash of potent grass rather than a lot of disappointment.

Moat people who grow marijuana plant it in their backyards. They hide the plants from curious neighbours and passers-by with walls, fences, arbor, or similar enclosures. Some people plant Cannabis as part of their vegetables garden, pruning the plants to make them less conspicuous.

Gardeners often use ingenious ideas to keep their gardens secret. A woman on Long Island grows over thirty large plants in containers in her drained swimming pool. Although some of the plants reach a height of 12 feet, they can't be seen over the enclosing fence.

A couple living near Nashville, Tennessee, took the roof off their three-car garage and painted the walls white to create a high-walled garden. Other growers use sheds with translucent roofs.

Guerilla Farming

Many growers feel safer planting away from their property. Should the garden be discovered, they are not in jeopardy. On the negative side, they usually lose the close contact and control that a home gardener has.

Urban gardeners use makeshift greenhouses, rooftops, vacant lots, and city dumps. Vacant lost that are overgrown with lush weeds can support a good crop, if the marijuana plants get a head start on the indigenous weeds.

Fields, forest clearings, railroad rights-of-way, stream banks, runoff and irrigation ditches, clearings beneath high-tension lines, deserted farms and quarries, overgrown fields, and abandoned houses have all been used as garden spots. In areas where hemp is a problem weed, people plant seeds from high-potency marijuana in the same fields where the weedy hemp grows. Growers harvest the plants in late July before they flower and before the fields are watched or destroyed by law enforcers.

Larger growers often look for rough, unpopulated terrain that is accessible only by plane, helicopter, four-wheel-drive vehicles, or long hikes. They avoid areas which hunters and hikers are likely to use before harvest.

Serious growers often find unusual places to start gardens. A grow in Chico, California, hacks through two hundred yards of dense underbrush and bramble to reach his clearing. In Oregon some growers maintain fields which are a gruelling eight-hour uphill hike from the nearest road. Some Florida farmers commute to their island and peninsula gardens by boats. A master gardener in Colorado lowers himself by rope to a fertile plain 50 feet below a cliff.

A farmer in Hawaii wrote, "The main concern is to grow in an undetectable place where the plants can still get enough sun. This is becoming very difficult to find and some very elaborate subterfuges have been developed. People on Maui are growing plants suspended from trees and on tree platforms! Around here

some people carry small plants in buckets far out on the lava fields where there is a light shading from Ohia trees and you don't leave tracks. Also people go into the sugarcane fields, tear out some cane, and put in their plants. I am sure many other things are being done."

12.3 Light

Marijuana is a sun plant. The plants will grow in partially shaded areas, but about five hours of direct sunlight are needed for development into a lush bush. Marijuana does best when it has direct sunlight all day. If it grows at all in a heavily shaded area, it will be dwarfed and sparse - a shadow of its potential.

Try to choose a place that maximises light. Flat areas get the most sunlight, but many growers prefer to use slops and hillsides which help to hide the plants. Southern slops usually receive more sun and stronger light than eastern and western slops, which are shaded in the afternoon and morning, respectively. Northern slopes are rarely used, since they get the least sunlight and are also the coldest. Steeper slops are shaded sooner than gradual slopes, and lower areas are shaded earlier than high ones.

Sunlight at high altitudes is more intense, because of the thinner atmosphere and the usually lower pollution. The atmosphere and pollutants at lower elevations absorb and scatter some of the solar radiation.

Backyard gardeners usually compromise between the need for maximum light and the need for subterfuge. An area that gets several hours of direct sunlight and bright unobstructed daylight for the rest of the day will do well. A garden exposed to the south usually gets the strongest light and is the warmest. Overhanging vegetation should be pruned so that the plants are shaded as little as possible.

Most marijuana strains are acclimated to tropical and semitropical latitudes, where the daytime is relatively short (10 to 14 hours, depending on season), but the sunlight is quite strong. At latitudes in the United States, the sun is not as intense (although in the summer the difference is small), but the days are longer, and the plants can grow extremely fast. It is not true that intense sunlight is needed to grow great marijuana. However, a summer characterised by clear sunny weather will usually produce a larger and slightly more potent crop than if the season is cloudy and rainy.

Sunlight can be maximised by adequate spacing and orientation of the garden. This is covered in section 14.

Chapter 13
SOIL

Of all the factors involved in growing plants, soil is the most complex. It has its own ecology, which can be modified, enriched, or destroyed; the treatment it receives can ensure crop success or failure.

There is no such thing as the perfect soil for Cannabis. Each variety can grow within a wide range of soil conditions. Your goal is garden soil within the range for healthy growth: well-drained, high in available nutrients, and with a near neutral (7.0) pH. Cannabis grows poorly, if at all, in soils which are extremely compacted, have poor drainage, and low in fertility, or have an extreme pH.

There are several soil factors that are important to a grower; these include soil type, texture, pH, and nutrient content. We will begin this chapter by discussing each of these topics in succession, and will then turn to discussion of fertilisers, soil-preparation techniques, and guerilla farming methods.

13.2 Types of Soil

Each soil has its own unique properties. These properties determine how the soil and plants will interact. For our purposes, all soils can be classified as sands, silts, clays, mucks, and loams. Actually, soils are usually a combination of these ingredients. If you look carefully at a handful of soil, you may notice sand granules, pieces of organic matter, bits of clay, and fine silty material.

Sandy Soils

Sands are formed from ground or weathered rocks such as limestone, quartz, granite, and shale. Sandy soils may drain too well. Consequently, they may have trouble holding moisture and nutrients, which leach away with heavy rain or watering. Some sandy soils are fertile because they contain significant amounts (up to two percent of organic matter, which also aids their water-holding capacity. Sandy soils are rich in potassium (K), magnesium (Mg), and trace elements, but are often too low in phosphorous (P) and especially nitrogen (N). N, which is the most soluble of the elements, is quickly leached from sandy soil. Vegetation on sands which is pale, yellowed, stunted, or scrawny indicates low nutrients, usually low N.

Sandy soils can be prepared for cultivation without much trouble. They must be cleared of ground cover and treated with humus, manure, or other N-containing fertilisers. In dry areas, or areas with a low water table, organic matter may be worked into the soil to increase water-holding capacity as well as fertility. Sandy soil does not usually have to be turned or tilled. Roots can penetrate it easily, and only the planting row need be hoed immediately before planting. Growers can fertilise with water-soluble mixes and treat sandy soil almost like a hydroponic medium.

Sandy soils are also good candidates for a system of sheet composting (spreading layers of uncomposted vegetative matter over the garden), which allows nutrients to gradually leach into the soil layers. Sheet composting also prevents evaporation of soil water, since it functions as a mulch.

Silts

Silts are soils composed of minerals (usually quartz) and fine organic particles. To the casual eye, they look like a mucky clay when wet, and resemble dark sand or brittle clods when dry. They are the result of alluvial flooding, that is, are deposits from flooding rivers and lakes. Alluvial soils are usually found in the Midwest, in valleys, and along river plains. The Mississippi Delta is a fertile alluvial plain.

Silts hold moisture but drain well, are easy to work when moist, and are considered among the most fertile soils. They are frequently irrigated to extend the length of the growing season. Unless they have been depleted by faulty farming techniques, silts are rich in most nutrients. They often support healthy, vigorous vegetation. This indicates a good supply of N.

Mucks

Mucks are formed in areas with ample rainfall which supports dense vegetation. They are often very fertile, but may be quite acidic. They usually contain little potassium.

Mucks range from very dense to light sandy soils. The denser ones may need heavy tilling to ensure healthy root development, but the lighter ones may be cleared and planted in mounds. Mucks can support dense vegetation, and are often turned over so that the weeds thus destroyed form a green manure.

Clay Soils

Clays are composed of fine crystalline particles which have been formed by chemical reactions between minerals. Clays are sticky when wet, and can be moulded or shaped. When dry, they form hard clods or a pattern of square cracks along the surface of the ground. Clays are usually hard to work and drain poorly. Marijuana roots have a hard time penetrating clay soils unless these soils are well-tilled to loosen them up. Additions of perlite, sand, compost, gypsum, manure, and fresh clippings help to keep the soil loose. Clay soils in low-lying areas, such as stream banks, may retain too much water, which will make the plants susceptible to root and stem rots. To prevent this, some growers construct mounds about six inches to one foot high, so that the stems and tap roots remain relatively dry.

Clay soils are often very fertile. How well marijuana does in clay soils usually depends on how well these soils drain. In certain areas "clay" soils regularly support corn cotton. This type of soil will support a good crop of marijuana. Red colour in clay soil (red dirt) indicates good aeration and a "loose" soil that drains

well. Blue or gray clays have poor aeration and must be loosened in order to support healthy growth.

A typical schedule for preparing a heavy clay soil In the late fall, before frost, turn soil, adding fresh soil conditioners, such as leaves, grass clippings, fresh manure, or tankage. Gypsum may also be added to loosen the soil. Spread a ground cover, such as clover, vetch, or rye. In early spring, making sure to break up the large clods, and add composts and sand if needed. At planting time, till with a hoe where the seeds are to be planted.

As the composts and green manure raise the organic level in the soil, it becomes less dense. Each year, the soil is easier to work and easier for the roots to penetrate. After a few years, you may find that you only need to turn under the cover crop. No other tilling will be needed.

Loams

Loams are a combination of about 40 percent each of sand and silt, and about 20 percent clay. Organic loams have at least 20 percent organic matter. In actuality, a soil is almost always a combination of these components, and is described in terms of that combination, e.g., sandy silt, silty clay, sandy clay, or organic silty clay. Loams range from easily worked fertile soils to densely packed sod. Loams with large amounts of organic matter can support a good marijuana crop with little modification.

13.3 Humus and Composts

Humus and composts are composed of decayed organic matter, such as plants, animal droppings, and microbes. Their nutrient contents vary according to their original ingredients, but they most certainly contain fungi and other microorganisms, insects, worms, and other life forms essential for the full conversion of nutrients. As part of their life processes, these organisms take insoluble chemicals and convert them to soluble forms, which plant roots can then absorb. Humus and composts hold water well and are often added to condition the soil. This conditioning results from the aerating properties and water-holding capacity of humus and composts, as well as balanced fertility.

Humus and composts have a rich, earthy small, look dark brown to black, and may contain partially decayed matter, such as twigs or leaves. They are produced naturally as part of the soil's life process or can be "manufactured" at the site by gathering native vegetation into piles. Composts cure in one to three months, depending on both ingredients and conditions. Decomposition can be speeded up by turning and adding substances high in N. Composts are frequently acidic and are sweetened with lime when they are piled. This also shortens curing time, since the desirable microbes prefer a neutral medium.

13.4 Texture

Soil texture refers to density, particle size, and stickiness, all of which affect the soil's drainage and water-holding characteristics. The most important quality of the soil for marijuana is that it drains well - that is, water does not stand in pools after a rain, and the soil is not constantly wet. In a well-drained soil, the roots are in contact with air as well as water.

Cannabis does best on medium-textured soils: soils that drain well, but can hold adequate water. Loams, silts, and sands usually drain well and are loose enough to permit good root development. Some clays and most mucks are too compact to permit the lateral roots to penetrate and grow. In addition, they often drain poorly, and when dry they may form hard crusts or clods, a condition marijuana cannot tolerate.

Several simple tests will indicate the consistency and drainage qualities of your soil. Test when the soil is moist but not wet. First, dig a hole three feet deep to check the soil profile. In a typical non-desert soil, you will find a layer of decaying matter on the surface, which evolves into a layer of topsoil. Most of the nutrients available to the plant are found at this level or are leached down from it. The topsoil layer is usually the darkest. It may only be an inch thick or may extend several feet. When in good condition, the topsoil is filled with life. Healthy topsoil contains abundant worms, bugs, and other little animals, and is interlaced with roots. If you can easily penetrate the underlying topsoil with your hands, its texture is light enough for healthy root growth.

The next layer, or subsoil, may be composed of a combination os sand, clay, and small rocks, or you may hit bedrock. Sandy, rocky, and loamy subsoils present no problems as long as the topsoil is at least six inches thick. Clay or bedrock often indicates drainage problems, especially if the spot has a high water table and stays wet.

Next scrape up a handful of soil from each layer. Press each handful in your fist, release it, and poke the clump with a finger. If it breaks apart easily, it is sandy or loamy. Clods that stick together, dent, or feel sticky indicate clay or muck.

To test for drainage, fill the hole with water. Wait half an hour to let the moisture penetrate the surrounding soil; then fill the hole with water again. If the water drains right through, you are working with sandy soil. If it doesn't drain completely within 24 hours, the soil has poor drainage.

13.5 pH

The pH is a measure of how alkaline (bitter) or acid (sour) the soil is. The pH balance affects the solubility of nutrients, and helps the plant regulate metabolism and nutrient uptake. The scale for measuring pH runs from 0 to 14, with 7 assigned as neutral. A pH below 7 is acid; a pH above 7 is alkaline.

Marijuana grows in soils with a pH range from 5 to 8.5, but it thrives in nearly neutral soils. Relative to other field crops, it has high lime requirements, similar to those for red or white clover or sunflower. But it does well in fields where plants with medium lime requirements, such as corn, wheat, and peanuts, are grown.

The solubility of nutrients is affected by soil type as well as by the pH. In soils with a high content of organic matter, all nutrients are soluble between 5.0 and 6.5. Phosphorous, manganese, and boron are less soluble at pH values above 6.5. Acid soils are usually found in the United States east of the 100th meridian and along parts of the West Coast, and a deep topsoil layer. Marijuana does best in acid soils when the pH is adjusted to a range of 6.3 to 7.0. {Figure 58. Map of pH for US.}

Mineral soils in the dry western states may be slightly acid to highly alkaline. Most nutrients are very soluble in these soils, as long as the pH ranges from 6.0 to 7.5. Some of these soils are too alkaline (over 8.5); so their pH must be adjusted to near neutral to ensure healthy growth.

Adjusting the pH

First test the soil pH in the garden area. Previous gardeners may have adjusted native soils, or your yard soil may have been trucked in to cover poor native soils, so that the pH of your garden soil may be different from that of other soils in the area. Different soils vary in the amount of material needed to adjust the pH. Sandy soils do not require as much as loam, and loam requires less than clays, partly because of the chemistry, and partly because of the density and physical qualities of the soils' particles.

Adjusting Acid Soils

Acidic soils are treated with limestone, which is expressed as an equivalent of calcium carbonate ($CaCO_3$). Limestone is usually quarried and powdered, contains large amounts of trace elements, and comes in different chemical forms: ground limestone, quicklime, and hydrated lime (which is the fastest acting form). Dolomitic limestone is high in magnesium and is often used to adjust magnesium-deficient soils, such as those found in New England. Marl (ground seashells) is also mostly lime and is used to raise soil pH. Eggshells are another source of lime. They should be powdered as finely as possible, but even so, they take a long time to affect the soil. Wood ashes are alkaline and very soluble; so they have an almost immediate effect.

Every commercial lime has a calcium carbonate equivalent or neutralising power which is listed on the package. To find out how much to use, divide the total amount of limestone required by the pH test (see Figure 59) by the calcium carbonate equivalent. For instance, a field requires fifty pounds of limestone, but the calcic limestone you are using has an equivalent of 1.78. Divide the 50 by 1.78. The resulting

figure, about 29 pounds, is the amount required. Commercial limes also list the grade or particle size of the powder. In order of fineness they are: superfine, pulverised, agricultural grade, and fine meal. The finer the grade, the faster the action. {Figure 59. Approximate amount of lime required to adjust pH of a 7" layer of different types of soil.}

For best results, lime should be added at least four or five months before planting. In this way, the lime has a chance to react with the soil. But acid soils can be limed profitably and time before planting, or after, as long as the lime does not come into direct contact with the plants. Most growers add lime at the same time that they fertilise and turn the soil. That way, tilling and conditioning are handled in one operation. The lime should be worked into the soil to a depth of ten inches. Lime can also be added by spreading it before a rain. Make sure that the soil is moist enough to absorb the rain, so that the lime does not run off. Growers who have not adjusted the pH can dissolve lime in water before they irrigate. However, this is not advised if the water runs through a hose or pump, because mineral buildup may occur in the equipment.

Adjusting Alkaline Soils

Most alkaline soils have a pH no higher than 7.5, which is within the range for optimum growth. Soils that are too alkaline can be adjusted by adding gypsum, which frees insoluble salts, and include iron, magnesium, and aluminium sulphate. Marijuana has a low tolerance for aluminium; so marijuana growers should use iron or magnesium sulphate in preference to aluminium sulphate. Sulphur and gypsum are worked into the soil in the same manner as lime.

{Table 19.}

Some growers correct alkaline soils by adding an organic mulch or by working acidic material into the soil. Cottonseed meal, which is acidic and high in nitrogen, can also be used. As it breaks down, cottonseed meal neutralises the soil. Pine needles, citrus rinds, and coffee grounds are all very acidic, and can be used to correct alkaline conditions. The addition of soluble nitrogen fertilisers aids the breakdown of these low-nitrogen additives. (See Table 22 in the section on "Fertilisers" in this section.)

Adjusting Alkali Soils

Alkali soils (pH usually above 8.5) are hardpacked and crusty, and sometimes have an accumulation of white powdery salts at the surface. They may not absorb water easily and can be extremely difficult to work. To prepare alkali soils with a permeable subsurface for cultivation, farmers leach them of their toxic accumulation of salts. The soils is thoroughly moistened so that it absorbs water. Then it is flooded so that the salts travel downward out of contact with the roots. Gypsum can be added to free some of the salts so that they leach out more easily. Gypsum can be added at the rate of 75 lbs per 100 sq.ft., or 18 tons per acre. Leaching requires enormous quantities of water, an efficient irrigation system, and several months.

{Plate 1. Skylights are a good source of bright, unobstructed light. Thai plant (closest) and Colombian plants reached over 14 feet in six months.

Plate 2. Top: A hidden garden using fluorescent light, foil reflectors, and bag containers. Plants are ten weeks old. Bottom: Simple to construct dome greenhouse in southern California. At two months, some of these plants are six feet tall.

Plate 3. Upper left: Stem of a female plant. Upper right: In full sunlight, a pruned plant can grow incredibly dense. Bottom: A garden in the wilds of Oregon mountains.

Plate 4. Marijuana does well in most gardens. Top: Here a female plant is in early bloom at five months. The main stem was clipped at three months (Berkeley). Middle: Lower branches are spread out to catch the sun. Bottom: A female bud about two weeks before harvest. Leaves show some damage from leafhoppers (insects shown).

Plate 5. A giant sinsemilla cola grown from Mexican seed in northern California.

Plate 6. Top: Purple colours often appear late in life, when vigour is waning. Lower left: Resin glands glistening on a purple, female flowering shoot. Lower right: Yellow male flowers and purple leaves against a normal green leaf.

Plate 7. Top: Male flowers at different stages in development. A line of resin glands can be seen on the anthers of the open flowers. Lower left: Resin glands lining the pollen slit of an anther (x40). Middle right: Male flowers in full bloom. The leaves are covered with fallen pollen. Lower right: Gland heads may fall with the pollen grains. Mature grains are spherical in field of focus (x40).

Plate 8. Top: Resin glands on the lower (adaxial) surface of a small, fresh leaf blade. Integrals are one millimetre (x16). Middle and lower left: Stalked glands are concentrated along the veins of the lower leaf surface (x40). Lower right (x100).

Plate 9. Top: Upper (adaxial) fresh leaf surface. Left of picture, from left to right: Sharp-pointed cystolith hair, stalked gland, and tiny bulbous gland (x40). Lower left: Upper surface of a Thai leaf (x16). Lower right: Upper surface of fresh homegrown Colombian leaf (x40).

Plate 10. A young female flower (homegrown Colombian). Resin glands are not yet fully developed (x16).

Plate 11. Top left: A mature female flower from the same plant is in Plate 10. The flower bract is swollen from the ripe seed it contains. Notice the well-developed resin glands (x25). Top right: A mixture of seeds from common marijuana varieties shows comparative size. Bottom: The tip of a sinsemilla flower at harvest. Notice cream-coloured stigmas to the left and the fresh, clear resin glands (x40).

Plate 12. Upper and lower left: An overly ripe sinsemilla flower bract. Many gland heads are brown or missing (top, x16; bottom, x40). Upper and lower right: Carefully handled Thai weed with intact glands. Notice the high concentration of glands and very long stalks on this bract (top, x16; bottom, x40).

Plate 13. Upper and lower left: A Colombian Gold. Gland contents are brown and stalks have deteriorated on this bract (top, x16; bottom, x40). Top right: Hawaiian; well-handled and showing little deterioration (bract x40). Middle right: Gland heads easily detach from stalks when overripe (leaf vein x40). Lower right: Stalked glands on both upper and lower leaf surfaces beginning to brown (leaf margin x40).

Plate 14. Top: Whitefly larvae and their honeydew excretions on the lower surface of a leaf. Middle left: Leaf showing whitefly damage and a tiny adult. Lower left: White speckles on leaves indicating mite damage. Lower

right: An overdose, or overuse of pesticide, can kill the plant.

Plate 15. Upper left: Healthy green plant next to a N-deficient plant. Middle left: Ultraviolet burn. Plant was moved outdoors without conditioning. Lower left: "Bonsai" marijuana grown from a cutting. Upper right: Mg-deficient plant has chlorotic leaves dying from their tips. Lower right: Afghani variety, with characteristically wide leaf blades, show minor symptoms of N deficiency (pale leaves and red petioles).

Plate 16. Upper left: Male flowers lose some green and turn "blond" during slow drying. Upper right: Cigar joints made with undried marijuana, which is wrapped with lone blades of fan leaves before drying. Bottom: Sequence shows change in colour in one day from sun curing.{Unfortunately, all the plates are in black and white.}}

Another method of reclaiming alkali soils is by adding a thick mulch and letting it interact with the soil during the winter. The mulch should be about nine inches thick, or 130 lbs or more per 100 sq.ft. This thick layer neutralises the salts and also helps to retain moisture.

Nutrients

Marijuana is a high-energy plant which grows quickly to its full potential in a fertile soil that is rich in available nutrients. Nutrients are found in the soil's parent materials: sand, clay, humus, minerals, rocks, and water. Nutrients dissolve in soil water (soil solution), which is then absorbed by the plant. In complex chemical processes, roots release ions in exchange for nutrients that are dissolved in the soil solution.

The soil acts as a reservoir for the nutrients. Most of them are in non-exchangeable forms: that is, they do not dissolve, or dissolve only slightly in water. Only a small percentage of the total reserve is free at any time as the result of chemical processes or microbial action. Healthy soils maintain a balance between free and unavailable nutrients, so that the plants they support continually receive the right amounts of required nutrients. Alkali soils have large supplies of compounds which are extremely soluble. The solution is so concentrated that alkali soils are often toxic to plants.

There are three primary nutrients, N (nitrogen), P (phosphorus), and K (potassium). These are the nutrients that gardeners are most likely to be concerned with and which most fertilisers supply. Soils are most likely to be deficient in one of these nutrients, especially N.

In addition to the primary nutrients, soil supplies plants with three secondary nutrients, Ca (calcium), Mg (magnesium), and S (sulfur), and seven micronutrients: iron, boron, chlorine, manganese, copper, zinc, and molybdenum. Although deficiencies of all the secondary and micronutrients are reported from various parts of the United States, serious deficiencies do not occur often. ((For a discussion of the symptoms of nutrient deficiencies is marijuana, see section 9.))

Marijuana absorbs nutrients primarily through a fine network of lateral roots which grow from the taproot. Lateral roots may spread over an area with a diameter of five feet, and may go as deep as the roots can penetrate. Plants in deep sandy soils or in soils that have porous mineral subsoils may grow roots as deep as even seven feet. Roots which can absorb nutrients from a larger area are more likely to fulfil the plants' needs than are shallow roots which result in shallow topsoil layers over compacted subsoils. When the roots have a large area from which to absorb nutrients, the soil does not need to be as fertile as when the roots are restricted to a small area by poor soil or by being grown in pots.

You can get a good indication of soil fertility by observing the vegetation that the soil supports. If the vegetation is varied, has a lush look to it, is deep green, and looks vigorous, it is probably well-supplied with nutrients. If the plants look pale, yellowed, spindly, weak, or generally unhealthy, the soil is probably deficient in one or more nutrients.

Testing

Agricultural colleges, County Extension Agents, and private companies perform soil analyses for a small fee from a sample you mail to them. The tests include nutrient, pH, and texture analyses, and are very accurate. There are also simple-to-use test kits available at nurseries and garden shops which give a fair indication of soil fertility and pH. Test results include a suggested fertiliser and lime program catered to the soil's individual requirements for the crop to be planted. Marijuana has nutrient requirements similar to those for corn, wheat, and sugarcane, and prefers just a little more lime (a more alkaline soil) than those crops; so soil can be fertilised as it would be for those crops.

Soil tests are one indication of soil fertility. They test for available nutrients, but not for reserves that are held in the soil. Test results may also vary because of recent rainfall, changes of moisture content, and seasonal changes. Most soil tests do not measure the ability of the soil to make nutrients available. This is a very important factor when considering a fertiliser program and should not be overlooked. As an example, an uncultivated field showed only moderate amounts of N available, and indicated a need for N fertiliser. The vegetation - tall grass, weeds, and bush - had a healthy look and was dark green, and the lower leaves remained healthy. Obviously, the soil was able to supply an adequate amount of N to the plants, which withdrew it from the soil solution as it became available. The soil and plants had reached a balance, and the soil solution slowly became more dilute over the course of the season.

To a great extent, the soil's ability to maintain a constant and adequate supply of nutrients depends on the soil's humus content. Humus can support dense populations of microorganisms. As part of their life processes, microorganisms decompose organic matter in the humus. Nutrients contained in the organic matter are released by microbes as simply inorganic molecules (e.g., NO3) which can dissolve in soil water. Generally, soils with a high humus content can keep plants supplied with more nutrients than soil tests indicate.

The Primary Nutrients

If you look at any fertiliser package, you will note three numbers on the package. They stand for N-P-K, always in that order. Marijuana does best in a soil which supplies high amounts of N and medium amounts of P and K.

Nitrogen

The availability of N is the factor most likely to limit the growth of marijuana. For fast healthy growth, marijuana requires a soil rich in available N. Nitrogen is constantly being replaced in the soil solution by microbial breakdown of organic matter. Some microorganisms can use N directly from the atmosphere. They release N as waste in the form NO3, which is the primary form in which plants absorb N. A small amount of N is also dissolved in falling rainwater. When the soil is moist, it loses N through leaching and to plants. In its available form (NO3, NO2, NH4), N is very soluble and may be carried away with runoff or may drain into the subsoil.

Probably the most accurate method of measuring a soil's ability to produce N is by the percentage of organic matter in the soil (see Table 20). Organic matter releases N at a rate that is determined by the type of soil, the temperature, and the moisture. Generally, the more aerated and warmer the soil, the faster organic matter decomposes and releases N. Most professional testing services report the percentage of organic matter, and some sophisticated kits can also test for it.

In its available state, N is tested in two compounds, ammonium (NH4) and nitrate (NO3). Test results are converted into PPM (parts per million) of N and then added to arrive at the total amount of N available in the soil. The formulas to convert nitrate and ammonium to N are (NO3) * 0.226 = N, (NH4) * 0.78 = N. Each PPM indicates 10.7 pounds of N per acre available in the top 7.87 inches. If the soil level is deeper, there is probably more N available. If it is shallower, less is available. But a test for available N gives only a fair approximation of the soil's ability to feed the plant. An individual test may be untypical because of recent leaching or depletion during the growing season.

An intensively cultivated crop of hemp takes about 250 pounds of N per acre or six pounds per 1,000 square feet from the soil during the growing season. When the plants are spaced well apart, the crop

does not require as much N.

Fields which have more than 200 lbs of available N per acre (or 4.5 lbs per 1,000 sq.ft.) at the start of the growing season require no additional fertilisation. Soils with less available N will probably yield a larger crop if they are given additional N. Actually, the amount of N that can profitably be used depends on the soil and its potential to produce N as well as on other factors: how fast N is lost, the soil depth, and moisture content.

One way to calculate the amount of N to add to the soil is to build your soil to an "ideal" level. For example, an Iowa silt loam may test about 1.6 pounds of N per 1,000 sq.ft. and an organic content of 3 percent. Together, the available and potential N total about 3.2 lbs per 1,000 sq.ft. To increase the available N to 4.5 per 1,000 sp.ft., you would need to add 1.3 lbs of N.

Phosphorus

P is an important nutrient which is used directly by the soil bacteria as well as by the plant, so that an increase in the amount of P in the soil often results in an increase of N. Because of P's low solubility, it is rarely leached from the soil. It is usually found in the greatest concentration in the soil's top layers, where it accumulates as a result of decomposition of organic matter.

In slightly acid organic soil, up to one percent of the total P is available at any time. The total amounts of P in soils range from 1,000 to 10,000 lbs per acre. For example, a typical Kansas prairie soil has 3,000 lbs per acre. In soils with a lower pH, more of the P is tied up in insoluble compounds of iron or aluminium. In highly alkaline soils, the P forms insoluble compounds with calcium.

Insoluble P reacts with the dilute acids that are released during decomposition of organic matter. These compounds are available to the plants. Both the chemical processes in which P is released and the organic processes of decomposition occur faster in warm soils.

If P is available, young plants absorb it rapidly, and may take in 50 percent of their lifetime intake by the time they are only 25 percent of their adult size. Young plants grown outdoors in cold weather may grow slowly until the soil warms up and more P is available. Older plants grown out of season in cold weather sometimes exhibit purple leaves. This condition may result from a P deficiency, because of the unavailability of P at low temperatures.

Most soil-test kits test available P, but the nutrient value of P is usually expressed as phosphoric acid (P_2O_5), which is converted using the formulas P * 2.3 = (P_2O_5),(P_2O_5) divided by 2.3 = P. Any soil that has available P of 25 lbs per acre (0.58 lbs per 1,000 sq.ft.) or more is well-supplied with P. Stated in terms of phosphoric acid, this is 25 * 2.3 = 57.5 lbs per acre (1.33 lbs per 1,000 sq.ft.).

Most inexpensive soil kits test available P. Soil that test less than 1 PPM or 10.7 lbs per acre (0.25 lbs per 1,000 sq.ft.) of available P should be tested to make sure there are adequate reserves, or can be fertilised to assure maximum yield. Soil-test kits give only a fair indication of the P available. A low reading may indicate the plants are absorbing P as fast as it breaks down from its unavailable form, especially during early growth! The main factors affecting the rate at which P becomes available are the total amount of reserve P in the soil and the pH.

Most professional soil analyses include a report of reserve P. Generally soils with reserve P of 3,000 lbs per acre (70 lbs per 1,000 sq.ft.) do not need additional P. Intensively cultivated and cropped fields may have had their reserve supply depleted, and will lock up available P that is supplied as fertiliser until a balance is reached.

Potassium

K is found in adequate quantities in most soils which have a pH within the range needed for growing marijuana. K is held in soils in three forms: unavailable, fixed, and readily available. Most K is held in the unavailable form as part of the minerals feldspar and mica. But a small percentage of the total K in any

soil is held in fixed, slightly soluble forms. Some of these can be absorbed and used directly by the plant. The exchangeable K is equal to a fraction of the fixed K. Each soil maintains a balance or ratio of unavailable to fixed and to exchangeable forms. Organic soils have a higher percentage of K in the fixed or available form than mineral soils. As K is used by the plants, some of the unavailable K goes into the more available forms. Plants can use K in both the soluble and the fixed forms.

Most clays and soils that are well-limed have adequate reserves of K. Acidic soils generally have low K reserves. Mucks, silts, and peats have low reserves of K, and have little capacity to hold it chemically when it is applied. Sands have K reserves, but little capacity to convert it to a fixed or available form. Most western soils have adequate reserves or K. The exchangeable K in soils becomes fixed if the soil dries out; so the available K of a recently dried soil is usually low.

K is tested in its elementary state, but when described as a nutrient, it is given as potash (K2O). The formulas for converting are K * 1.2 + (K2O),(K2O) divided by 1.2 + K. Soils with 180 lbs or more of available potash per acre (4 lbs per 1,000 sp.ft.) have an adequate supply. The total reserve K should test no lower than 900 lbs per acre (21 lbs per 1,000 sq. ft.).

The Secondary Nutrients

Magnesium (Mg), calcium (Ca), and sulfur (S) are usually found in adequate quantities in soils suitable for growing marijuana. However, some New England soils do have Mg deficiencies. Soils which have a neutral or near-neutral pH almost always have adequate Ca and sulfur levels.

Magnesium deficiencies are corrected by adding 50 to 100 lbs of Mg per acre (2.25 lbs per 1,000 sq.ft.). The most inexpensive way to add Mg is to use a dolomitic limestone for adjusting soil pH. Dolomitic limestone is about 12 percent Mg (see Table 21); so 800 lbs of it are needed to supply 100 lbs of Mg. Dolomitic limestone releases Mg to the soil gradually. For faster action, epsom salts (magnesium sulfate, MgSO4) can be used. Five hundred lbs of epsom salts are required to supply soil with 100 lbs of Mg. Mg deficiencies can also be corrected by using foliar sprays. Dissolve one ounce of epsom salts in a gallon of water and spray all foliage.

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{Picture  The relationship between soil pH and relative plant nutrient
availability.  The wider the bar, the more the availability.  This chart is
for soil types recommended in this book..
        {Nitrogen - pH of 6.3 to 8
         Phosphorus - 6.5 to 7.5
         Potassium - 6.5 to 9
         Sulfur - 6 to 9
         Calcium - 6.7 to 8.5
         Magnesium - 6.5 to 8.5
         Iron - <4 to 6
         Manganese - 4.7 to 6.5
         Boron - 5 to 7 or 9
         Copper and Zinc - 5 to 7
         Molybdenum - 7}}
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Micronutrients

Micronutrients are used by plants in minute quantities, and most soils contain enough of them to meet plant requirements. Home gardeners and guerilla farmers seldom encounter any micronutrient deficiencies. But heavily cropped lands sometimes develop a deficiency of one or more micronutrients because of crop depletion. Micronutrients are made available to the plants only if there is a delicate balance in the soil chemistry, and it is easy to create toxic conditions by adding them to soil when they are not needed. For that reason, soils should be treated with micronutrients only when symptoms occur or when the deficiency is known by analysis or past experience. Only small quantities of additives are required for treatment. Manures, composts, other organic fertilisers, lime, rock powders, and ash contain

large quantities of trace elements. Active organic additives quickly release micronutrients in a form that is available to the plants.

Boron

Boron deficiencies in marijuana occur in acid soils as a result of depletion by heaving cropping. The areas most affected by it are vegetable fields in the mid-Atlantic states, alfalfa and clover fields east of the Mississippi, and truck farms and orchards in the Northwest. Boron is found in phosphate fertilisers, gypsum, and lime, and is the main ingredient of boric acid and borax. When borax or boric acid are used, they are applied at the rate 10 to 20 lbs per acre. They are used as a foliar spray at the rate of 1 ounce per gallon of water.

Chlorine

Chlorine deficiency does not normally occur. Some chemical fertilisers contain chlorine, and toxic conditions occur infrequently. Toxic chlorine conditions are eliminated by leaching.

Copper

Copper deficiencies occur infrequently in truck farms in Florida, California, and the Great Lakes region. Wood shavings and tobacco contain large amounts of copper. A foliar spray composed of 1 ounce each of calcium hydroxide and copper sulfate (a fungicide) per gallon of water is used by commercial vegetable growers.

Iron

Iron deficiencies occur in orchards west of the Mississippi and in Florida, and in alkaline soils in which iron is largely insoluble. Lowering soil pH often solves the problem. Chelated iron, which is water-soluble, is available at most nurseries and quickly supplies iron even when pH is extreme. Humus and seaweed are excellent sources of iron.

Manganese

Manganese deficiencies occur in the Atlantic states, the Great Lakes area, Utah, and Arizona. Manganese is found in manure, seaweed, and some forest leaf mould (especially hickory and white oak). Manganese deficiencies can be corrected by using a foliar spray of manganese sulfate at the rate of 0.5 to 1.0 oz. per gal. Soil is sometimes treated with manganese sulfate at the rate of 20 to 100 lbs per acre. In neutral or alkaline soils, most of the manganese sulfate becomes fixed and unavailable to the plants by the end of the growing season.

Molybdenum

Molybdenum deficiencies occur primarily along the Atlantic and Gulf coasts and in the Great Lakes region. Plants need extremely small amounts of molybdenum, less than 1 PPM in leaf and stem tissue. Molybdenum deficiencies occur when the soil is too acidic. By raising the pH level, one can make molybdenum available.

Zinc

Zinc deficiencies occur in soils throughout the U.S., primarily because of heavy cropping. It is most likely to occur in acid-leached sandy soils, and in neutral and alkaline soils where it is insoluble. In soils with high amounts of available P, zinc is also unavailable. Many deciduous tree leaves and twigs, composts, slag, and rock phosphate contain large amounts of zinc. Zinc sulfate is used as foliar spray at the rate of 3 oz. of zinc sulfate per gallon of water, or as a soil treatment at the rate of 100 lbs per acre. Some orchard growers drive galvanised nails into the trees to provide zinc.

13.6 Fertilisers

Most soils can benefit from a realistic soil-conditioning program. Most organic programs build soil, and minimise leaching and runoff. Programs using chemical fertilisers emphasise immediate increase in yield and a minimum of labor. The approach that you use should be tailored to the soil's needs and to your situation and goals. For example, a home gardener interested in building soil quality can easily add manure or compost to his garden. But a guerilla farmer may use concentrated chemical fertilisers, which are easy to transport to a remote area. A farmer cannot use the labor-intensive techniques which a small planter might use as a hobby. Many gardeners use both organic and inorganic fertilisers.

Organic Fertilisers

Organic fertilisers are usually less concentrated than chemical mixes. Their bulk consists of fibrous materials which condition the soil by aiding drainage and increasing the organic content and water-holding capacity. As they are decomposed by microbial action, the nutrients they contain are released in soluble form. Since this is a gradual process, there is little chance of creating toxic conditions.

Manures and composts are basic, all-purpose conditioners. They contain adequate amounts of most of the nutrients that marijuana absorbs from the soil and can be used generously. Uncomposted manures are "active" and should be used only in the fall. Over the winter they compost in the ground. Composts and composted manures can be added in the spring. Table 22 lists some common organic fertilisers which are usually available. Some of them, such as bone meal and granite dust, break down slowly and are available only after a period of time. Others are low or lacking in one or more of the major nutrients. Organic fertilisers can be combined to provide a complete balance.

Chemical Fertilisers

Most chemical fertilisers act quickly because all the nutrients are in soluble form. They are usually more concentrated than organic fertilisers, and can toxify the soil and kill the plants when they are overused. Fertilisers come in various concentrations and ratios of nutrients. All packaged fertilisers list the percentages of N-P-K (actually n-(P2O5)-(K2O)). Also listed is the potential acidity or alkalinity, that is, the number of pounds of lime or sulfur required to counteract pH changes caused by the fertilisers. Chemical fertilisers are often incompatible with each other; so home gardeners who use them should buy them pre-mixed or as a complete component fertiliser set.

Solubility is a major problem with commercial fertilisers. In irrigated areas as well as areas with rainfall during the growing season, they are likely to be leached away; so they must often be applied several times during the growing season. A typical program might be to fertilise at planting and every six weeks thereafter until the beginning of flowering. When spreading fertilisers during the growing season, do not let them come into direct contact with the roots. An easy way to fertilise during the growing season is to make a small trough between rows with the corner of a hoe. Fertiliser is placed in the depression. Some new chemical formulas release nutrients during the length of the growing season, and therefore need only one application.

Amounts to Use

The amounts of nutrient needed per acre and per 1,000 sq.ft. are shown in Table 23. Soils rich in one nutrient may be average or deficient in another. To calculate the required amount of a specific fertiliser, divide the amount of nutrient required as listed in the chart by the percentage of nutrient in the fertiliser. For instance, to add 5 lbs of N to an area by using bloodmeal, divide 5.00 by 0.15. The total comes to a little more than 33 lbs. Dried cow manure contains about 1.5 percent N. About 333 pounds of it are needed to supply 5 lbs of N. Urea, a chemical fertiliser, contains 46 percent N. Only 11 pounds are required to supply 5 lbs of N.

Planning a Garden Fertiliser Program

Now let's plan some garden fertilisation programs, to help some cultivators in three areas which have different soils and climates: New England, Kansas, and Florida. We'll see how growers with different goals adjust their garden soil.

New England

Most New England soils, and many soils in humid temperate areas, have a thick layer of humus which supplies N. New England soils also contain moderate amounts of P, but they are low in K.

Our first gardener has a typical New England soil in his backyard. From tests and observation he thinks his soil contains moderate amounts of N and P, but is low in K. A test indicated a pH of 5.8. He plans to start preparing his ten-foot-square plot (100 sq.ft.) in the fall, before frost. By planting time, he expects his backyard garden to have a pH of 6.7 and a balanced, fertile soil.

From Figure 59 he finds that the soil requires about 8.1 lbs of lime. He has decided to adjust the pH by using dolomitic limestone (with a calcium carbonate equivalent of 0.45) because farmers in the area sometimes complain of Mg deficiencies. Dividing 8.1 by 0.45, he finds that the soil requires 18 lbs of limestone. (Lime requirements divided by calcium carbonate equivalent equals the amount of limestone needed.)

He guesstimates that the N content of his soil rates between fair and medium, and figures the soil can use almost 0.2 lbs of N. He has decided to spread fresh manure from a nearby stable mixed with lime. In the spring he will turn this into the soil; at the same time, he will add manure composted with hay and table scraps. The fresh horse manure contains about 0.44 percent N. To find out how much manure he needs, he divides 0.2 (the amount of N required) by 0.0044. The total comes to about 45.5 lbs. (Nutrient required divided by percentage in fertiliser equals amount of fertiliser needed.) The manure also contains 0.17 percent phosphoric acid (P_2O_5) and 0.35 percent potash (K_2O), referred to hereafter in this chapter as P and K, respectively. Multiplying 0.17 percent (0.0017) and 0.35 percent (0.0035) by 66 lbs, he finds that he has added 0.11 lbs of P and 0.23 lbs of K. (Lbs of fertiliser times percentage of nutrient in fertiliser equals amount of nutrient in fertiliser.)

> BOX F
>
> Chemical fertilisers usually supply P in the form of superphosphate or triple superphosphate. These chemicals are manufactured by mixing rock phosphate with acids. Potassium is supplied by means or muriate of potassium (K and chlorine) or sulfate or potash, which are mined in the Southwest and purified. All these chemicals are soluble and are available to the plant. But a portion of them gradually reacts with the soil and becomes fixed or unavailable. As this portion becomes unavailable, it increases the total reserve in the soil, which reaches a new balance of available to unavailable nutrients than before fertilisation.
>
> Bone meals and rock phosphate, the most commonly used organic sources of P, and granite dust, a source of K, are not readily available, but increase the total reserve of nutrients and gradually increase the total amount of available nutrients. However, there is some time lag before these nutrients are available to the plant. They are usually applied in large amounts, at about three times the weight calculated for fertilisers of that concentration. But one treatment lasts four years or more, because the fertilisers remain fixed in the ground until they are used. {Table 24}

From Table 23 he finds that the soil requires about five ounces of P. How many ounces of P is 0.11 lbs? He multiplies 0.11 by 16, the number of ounces in a pound, and finds that the total is about 1.75 ounces. The soil requires another 3.25 ounces. Bone meal is about 20 percent P. To supply three ounces of P, about a pound of bone meal is required. But bone meal breaks down slowly, and is therefore applied at three times the rate used for other fertilisers; so our cultivator uses 3 lbs.

Since the K content of this New England soil is poor, about 0.3 lbs of K is required. The manure has already supplied 0.2 lbs; so the soil requires another 0.1 lb. Our cultivator decides to use wood ashes from his fireplace. Wood ashes are about 7.0 percent K. He divides 0.1 by 7 percent (0.07) and finds that the soil can use at least 1.4 lbs of ashes. He adds this in the spring just before planting, because the ashes are highly soluble. Over the winter, such highly soluble nutrients would leach away or become

unavailable.

Our grower knows that some of the N in the fresh manure that was added in the fall will leach away during the winter. But the manure compost that he adds in the spring will more than make up for any losses.

A New England farmer not for from the cultivator has been rotating his field from corn and marijuana to alfalfa and pasture for the past ten years. Each fall he adds 7 tons of manure per acre. Except for occasional additions of lime, no other fertilisation is necessary.

A rural New England grower has decided to plant in a remote mixed-forest area. The first 10 inches of soil is a rich compost of humus. It is full of life: insects, worms, and other creatures. The grower has decided to increase the fertility of the soil by using chemical mixes and dolomitic lime. He is cultivating in three clearings with a total area of about 1,000 sq.ft. He guesstimates that the soil is medium in N and P, but poor in K. It is also acid. He applied enough lime to correct the soil's natural acidity and the pH of the fertiliser.

Using Table 23, he decides that he should purchase a mix with a ratio of 50 parts of N, 10 parts of P (reading from the medium line), and 120 parts of K (from the poor line), that is, a ratio of 5-1-12. A local nursery sells commercial fertiliser with nutrient percentages of 10-5-25, close enough to the desired ratio. By taking the total amount of N required for a medium soil as listed in Table 23 (19 ounces), and dividing it by the N in the fertiliser (10 percent or 0.10), the rural grower finds the total amount of fertiliser required (190 ounces, or a little less than 12 lbs). The other nutrients are automatically added in the same ratio.

Kansas: A cultivator in Kansas decides to plant along a hidden stream bank. The banks are covered with lush vegetation as a result of runoff that contains soluble fertilisers used on nearby farms. The cultivator feels that additional fertilisers are not necessary, since the vegetation is so lush.

Another grower in Kansas found that her soil was very low in N and P, but high in K, typical of dry midwestern and western soils that support scrub vegetation. It had a nearly ideal pH. She started to prepare her 200 sq.ft. garden in the spring after the rain season ended. Using Table 23, she found that it required 3.5 lbs of N, 6 ounces of P, and no K. Activated sludge (5-3-0) was available at the local garden centre. To find out how much sludge her garden required, divide 3.5 by 5 percent (or 0.05). The total comes to 70 lbs.

Florida: A grower planting 500 sq.ft. on a deserted ranch in central Florida started with a very sandy soil whose pH was 4.9 because of sulphurous water in the ground. From Figure 59, she found that the soil required about 35 lbs of lime. To adjust the pH, she used 14.0 lbs of a limestone with a calcium carbonate equivalent of 2.5.

The soil had virtually no organic matter, and she was not sure she could use the same location next year; so she decided to apply soluble mixes throughout the growing season. From Table 23, she found that "poor" required 28 ounces of N, 4 ounces of P, and 24 ounces of K. A chemical fertiliser with nutrient percentages of 15-5-10 was on sale at a local discount store. To find out how much fertiliser is needed to supply 28 ounces of N, divide 28 by 15 percent (or 0.15); the result is about 186 ounces of N, or about 11.5 pounds. Since the other nutrients are supplied at the same proportions or at higher proportions than are required, no supplements are needed at planting time. But additional feedings will be required periodically during the growing season.

13.7 Techniques for Preparing Soils

Each garden situation is unique, and many factors help determine which garden techniques you should use. These include the soil's condition, the size and location of the garden, commitment, and personal preferences. Each technique affects the microecology in its own way. Home gardeners may use techniques that are impractical for a farmer or guerilla planter. But all growers have the same goal when they prepare soil for planting: to create a soil environment conducive to growing a healthy, vigorous plant.

BOX G Fertilising Cannabis Depends on the Crop

> Historically, Cannabis is known to require high fertility. In a fertile soil, Cannabis can outgrow practically any annual plant. Cannabis also is a known depleter of soils. This is true particularly with marijuana, since seeds, flowers, and leaves comprise the harvest. Hence it's necessary to fertilise the plants each year. Hemp, on the other hand, comes from the Cannabis stem, and the fibre consists primarily of cellulose (C6H10O5)n. When hemp is grown, all plant parts except the fibre are returned to the soil; so the nutrients are also returned. Moderate fertilisation, if any, is all that's required for hemp farmers.

If you are already growing a vegetable garden, the chances are that your soil is in pretty good shape for growing marijuana. However, vegetable gardens may be a little acidic, particularly east of the 100th meridian. The soil should be prepared in much the same way that it is prepared for corn cultivation, with the addition of lime to raise the pH to near neutral.

Tilling

Gardens which may not have been planted recently (in the last three or four years) require more work. It is best to begin preparing the soil in the fall, before the first frost. This can be done using a spade or shovel. The ground is lifted from a depth os six or eight inches and turned over so that the top level, with its grass and weeds, becomes the bottom layer. Large clumps are broken up with a blade or hoe. Larger areas can be turned with a power hoer or rototiller. Conditioners, such as fresh leaves, composts, mulching materials, pH adjusters, and slow-release fertilisers are added and worked into the soil, so that they begin to decompose during the winter. It is especially important to add these materials if the soil is packed, mucky, or clay-like. Soluble fertilisers should not be added in the fall, since they leach to the subsoil with heavy rains.

In the spring, as soon as the ground is workable, turn it once again. If the soil still feels packed, add more conditioners. If you are using manure or other organic materials, make sure that they are well decomposed and small clean and earthy. Fresh materials tie up the N in the soil while they cure, making this nutrient unavailable to the plants. Commercial fertilisers and readily soluble organics, such as blood meal and wood ash, are added at this time.

The ground can also be seeded with clover or other legumes. Legumes (alfalfa, clover, vetch, etc.) are plants which form little nodules along their roots. The nodules contain bacteria which live in a symbiotic relationship with the plant. As part of their life processes, these bacteria absorb gaseous nitrogen from the air and convert it into a chemical form the plant can use. During its life cycle, clover uses up most of the N, although some leaks into the surrounding soil. But when the plant, or any of its leaves, die, the contents become part of the soil. The process of growing a cover crop and turning it into the soil is sometimes called green manuring.

After the last threat of frost, at about the same time that corn is planted, the soil should be worked into rows or mounds, or be hoed. At this time, the seeds should be planted. If any concentrated fertiliser is added to the soil, it should be worked into the soil and should not come into direct contact with the seeds.

The actual amount of tilling that a given soil requires depends on soil condition. Sandy soils and light loams may need no turning, since they are already loose enough to permit the roots to penetrate. Turning may break up the soil structure, damaging its ecology. These soils are easily fertilised, by using soluble mixes or by the layering technique described below. Soils which are moderately sandy can be adjusted by "breaking" and levered or pushed, but the soil is not raised. This is done about every six inches, and can be accomplished quickly. Farmers can loosen sandy soil by disking at five or six inches.

Some gardeners mulch the soil with a layer of leaves or other materials to protect it from winter winds and weather. This helps keep the soil warm so that it can be worked earlier in the spring. In states that border west of the 100th meridian, this helps prevent soil loss due to erosion from dry winds. Soil often drains well in these areas, and the ecology of the soil is better served when it is left unturned. At season's end, marijuana's stem base and root system are left in the ground to help hold topsoil. The next year's crop is

planted a cover crop, such as clover, or alfalfa, which holds the soil and also enriches the nitrogen supply.

Layering

Layering is another method of cultivation. The theory behind this program is that in nature the soil is rarely turned, but builds up, as layer after layer of compostable material falls to the ground. This material, which contains many nutrients, gradually breaks down, creating a rich humus layer over a period of years.

The layering method speeds up the natural process. Since gardens are more intensely cultivated than wild fields, new material is required to replenish the soil nutrients. Gardeners like Ruth Stout "sheet compost," that is, they lay down layers of uncomposted material and let it decompose at the same time that it serves as a mulch. But most gardeners prefer to use material which is already composted. The compost shrinks and builds the topsoil layer about an inch for every six inches of compost. After several years, the soil level will be raised considerably, and the top layers will be an extremely rich, porous medium which never needs turning. In order to prevent a spillover of the soil, gardeners usually construct simple beds (using boards) to contain the garden areas.

Layering is most successfully used on porous soils, especially sands, which contain little organic matter. It can also be used with clay soils. However, experienced growers say that clays should be turned several times before the technique is used, or the first couple of harvests will be small.

Planting a cover crop such as clover will give the soil structure. As more compost is added, the clover is covered and the new seed planted. The clover, with its N-fixing properties, remains a permanent cover crop. When marijuana seeds are to be planted, a planting row is easily tilled with a hoe. The clover protects the soil from sun-baking and its resulting water loss, and makes it harder for weed seeds to get started.

Tilling and layering are basic methods which are used with many variations. In some ways, there almost seem to be as many gardening techniques as there are gardeners. For instance, one gardener bought three cubic yards of topsoil and a cubic yard of composted steer manure. He mixed the material and filled raised beds with it to a depth of 18 inches, and had an instant high-power garden. Another grower made compost piles in his raised troughs during the winter. By planting time, the compost was complete and filled with earthworms. The beds became warmer earlier, and he could plant sooner.

A midwestern gardener used marijuana as a companion crop in much the same way Indians used corn. In between the marijuana, she planted beans and squash. She didn't get many stringbeans and only a few squash. But she believes that the beans gave the plants extra N, especially during the first six weeks, and the broad squash leaves protected the soil from the hot August sun.

A gardener in Georgia had such a sticky clay soil that a shovel once got stuck in it. He dug holes two feet deep and two feet wide with a power auger and filled them with a fertile mix of two parts sand, one part clay, three parts topsoil, and one part chicken manure. He claimed that his plants grew six feet in 10 weeks. Filling holes with a rich soil mixture is popular with guerilla farmers, who often must plant in poor native soils.

Mulching

Mulching is a labor-saving technique that many gardeners and farmers use for a multitude of reasons. A mulch placed on the ground before fall frosts helps the soil retain heat and protects it from winds and freezing temperatures. In the spring the mulched soil becomes warmer earlier in the season, and can be planted several weeks sooner than usual. A mulch cover keeps the seedlings' roots warm and eliminates a lot of weeding, since most weed seedlings cannot pierce the cover.

During the summer, mulches keep the ground cooler and more moist by absorbing and reflecting light and reducing surface evaporation. These are important points for farmers in dry areas. The water savings can be 50 percent or more.

Any plant or animal material will do for mulch. Gardeners use hay or straw, leaves, composts, manures, sawdust, bark, or plant clippings in two- to six-inch layers. A barber in Palo Alto uses hair. Baled hay is inexpensive and easy to use as a mulch. Round hay bales unroll in a long sheet that is easy to spread over the ground, and square bales can be pulled apart into tile-like squares.

Mulches create an ideal environment for earthworms and microorganisms which condition and enrich the soil. These organisms require a relatively cool, moist, dark environment. The mulch develops a dry outer crust which reflects light, keeping the underlayers cool and moist. Materials such as leaves, bark, and sawdust decay slowly because they do not contain enough nitrogen to maintain dense populations of decomposing microorganisms. Manures and composts contain more nitrogen and decay more quickly.

With few exceptions, mulches can be applied practically any time of the year, but the best time is probably in the fall, after the crop is harvested and before the ground has frozen. Leaves, plant clippings, and straw are applied in a thick layer from six to ten inches deep. Hay is layered two to six inches deep. Denser substances, such as manures and composts, should be mixed with straw and leaves to aid decomposition. This mixture is spread in an even layer, about two to four inches deep, over the entire surface of the garden. If winds pose a problem by blowing the mulch away, you can cover it with newspapers or sheets of plastic held down with rocks. If your area is dry, give the mulch a good soaking once before frosts.

By the spring, much of the material will seem to have disappeared. But underneath the top layer, you will find a soft-textured, earthy-smelling humus, teeming with worms, insects and other small animals. This is a sign of a healthy ecosystem and a fertile soil.

Some people apply mulch in the spring, placing it between rows as they sow the seeds. The mulch keeps weeds from competing with the seedlings, absorbs the sun's warmth, and releases nutrients to the soil.

In cold areas, such as Montana, New England, and Alaska, growers place black plastic sheets over the soil. These absorb the sun's heat, allowing the soil to be planted sooner. The seedlings develop quickly in the warmer soil. The plastic is removed once the seedlings are well-established.

Newspapers and white plastic can be used to decrease water loss during the summer. They also reflect light back to the plants.

One innovative grower from western Colorado placed a sheet of white plastic over her garden and cut out holes wherever she plant the seeds. Though it is quite dry where she lives, she didn't need to water the plants until late July. And she had no problems with any weeds.

Containers

Containers are another option open to grower. Plants can be grown full-size in containers which are at least five gallons (larger would be better). Fill them with high-grade topsoil, or a plating mixture as described in section 6. Planters are a convenient compromise where the soil is particularly poor or for the home gardener who does not wish to get into large-scale gardening. But remember, eight good-sized plants can yield over four pounds of grass.

Plants in pots need to be watered frequently, but require much less total water than a garden. The gardener can also move the plants. Some gardeners use this technique to maximise the amount of sun the plants get during the day, or as the sun's position changes with the season. And growers can easily induce early flowering by moving the plants to a darkened area. {Figure 61. Containers are convenient for outdoor gardens.}

Almost any large container that can withstand the weight of moist soil and which has holes for drainage is suitable. Containers which held toxic chemicals, herbicides, insecticides, or other possibly harmful substances should be avoided.

We have seen all kinds of ingeniously made containers. Some growers use old bathtubs, and others use

wooden packing crates or bushel baskets. A simple wood container 18 inches wide, eight feet long, and 18 inches deep was made by a New Jersey grower, who grew six plants in it. Trash cans, plastic containers, barrels, and even rubber tyres have been used. One grower grew plants in one-cubic-foot bags of soil by cutting a five-inch-diameter hole in the top and poling holes for drainage. To assure drainage, growers sometimes fill the bottom of each container with a six-inch layer of stones or gravel; is you are planning to move such container, lightweight perlite would be more suitable.

13.8 Guerilla Farming

Guerilla growers often use the same techniques as home gardeners. But the soil that they start with is sometimes marginal, and the gardens are in remote, hard-to-get-to areas; so they modify the techniques to fit their needs. When it is impractical to carry bulky organic fertilisers to the growing site, guerilla farmers use highly concentrated commercial mixes. Compost and soil adjusters are gathered from the surrounding area, and the simplest, most light-weight tools are used. Some growers use horses or mules to carry equipment and material, and then use the animal to plough. The animals are quiet and, naturally, require no external power source. Experienced growers say that the animals can work as fast as or faster than a rototiller.

It is hard to generalise about details of guerilla farming, since much depends on the specific circumstances, which can vary greatly. For instance, a grower who plants along the fertile bank of a midwestern stream may not need to do more than pull out weeds and till the actual planting area. But a grower planting on a mountain slope may have to "build a soil," since soil and nutrients are washed from the slopes and down to the valleys by rainfall. For this reason, we will cover several situations separately: forest; washed-out steep areas; swamps and marshes; stream banks; grasslands and fields; and arid soils.

Forest Clearings

Clearings in forests have always been popular places to plant because they offer security from detection. They vary greatly in drainage qualities, fertility, and pH. The drainage qualities of forest soils depend on the depth of the humus layer and the structure of the underlying subsoil. But most of the forest remaining in the U.S. is sloped, and water that is not absorbed by the soil runs off.

Soils are created in forests from the leaves, branches, animal droppings, etc., which accumulate on the forest floor. The first trees to grow are long-leaf pines, such as jack pines, which can grow in relatively infertile soils. Their roots penetrate deep into the subsoil to obtain some nutrients. Short-leaf pines, conifers, and firs appear as the humus accumulates, since they require a more fertile soil than long-leaf pines. Pine-forest soils vary in fertility from poor to fair, and are usually quite acidic. In the Northeast their pH may be as low as 3.5, but generally the pH ranges from 5.0 to 6.0. In order to support a high-energy, lime loving crop like marijuana, they require fertilisation and liming. Long-leaf pines sometimes grow in compacted clay soils, which also requires tilling.

As the soil evolves, deciduous trees (tree that drop their leaves each winter), such as oak and maple, may begin to grow. Deciduous forests, sometimes called broad-leaf or hardwood forests, have the best soils. These forest floors are covered with bushes, grasses, mosses, and other small plants. They have an adequate rainfall and a humus-rich soil, which is porous, holds water well, and can support a healthy marijuana crop, although additions of nitrogen fertilisers would probably spur growth. Hardwood forest soils have a pH range from 6.0 to 7.5. The soil in timbered forest land has a much smaller humus content, especially if it has been clearcut.

Mountain Soils and Washed-Out Steep Areas

Mountain slops characteristically have little soil matter; their surface is composed largely of rocks, gravel, and sand. For longterm use they could be terraced so the newly formed soil in not washed away, but most growers are interested in more immediate results. These "soils" do not provide much of an anchor for marijuana's taproot and do not permit a network of lateral roots to form. Many of these soils also suffer from a low water table, since they drain rapidly. But there may be some sand and a bit of organic matter

built up along gullies or in depressions or other natural traps. Such soil has usually had most of its nutrients leached out, but may contain some phosphates and potassium and considerable amounts of trace elements. The easiest way to adjust these soils is to use a well-balanced, slow-release, concentrated fertiliser. Bloodmeal, with its high N, works well with these soils.

One grower in the badlands of North Dakota used a timed-release 32-9-26 fertiliser in his "rock garden." He spread it just below the surface at the beginning of the growing season. Every time that it rained, his plants received nutrient-rich water. Toward the middle of the season, he noticed the lower leaves begin to pale, so he fertilised them periodically with urea. Heavy rains leach soluble fertilisers away, and in rainy areas they need to be applied three to four times during growth.

Containers can also be used in this environment. Growers use plastic bags or folded milk cartons instead of backpacking with a column of containers. When they get to the site, they fill the bags with a mixture of sand, as much as they can find, and gravel. The greater the ratio of sand to gravel, the longer the container will hold water.

One grower doublelayers heavy-duty polyethylene bags, and lines them with heavy-duty paper cement sacks or burlap bags. He fills the bag with gravel, then pours in sand and shakes it. He says that the mix is just about right when it looks like a can filled with gravel with sand in the spaces. He carries on a watering and feeding program much as he would for any hydroponic system.

Swamps, Marshes, or Bogs

These soils are very high in fibrous organic material, but are low in calcium and in available N, P, K, and Mg, which are leached from the soil or are insoluble because of the low soil pH. Since these soils are constantly wet, Cannabis roots cannot come in contact with air; as a result, the plant's growth is stunted, and the lower stem becomes susceptible to stem rot. These soils need to be adjusted to support a healthy crop of marijuana; they must be drained, fertilised, and limed. On a small scale, the easiest way to modify them is by constructing raised mounds, hills, or rows, at least one foot wide at the top and two feet high. The raised areas drain well, leaving relatively dry soil. Wood chips, chopped brush, sawdust, or perlite may be added to keep the mound light and the soil loose and aerated.

Wet soils are usually highly acid and should be limed. Once the lime interacts with the soil, nutrients which were locked up become available to the plants. Since these soils are rich in organic matter and have a high rate of microbial action after they are loosened and limes, they may need little fertilisation.

Grasslands and Fields

These soils are usually fairly fertile and can support a worthwhile crop with little effort. They are usually well-drained, although they may be a little too dry or too wet. (If they have unusually large numbers of earthworms, they are probably a little too wet.) Their pH is usually between 5.5 and 6.5, although it may range up to 7.0. These soils are usually loams, which need only tilling in a two-foot radius, three or four inches deep, around each plant. All weeds and grass should be pulled from the area. Some growers mulch the cultivated area with newspapers, leaves, or dead grass. A grower in the Midwest adds crushed eggshells and a commercial timed-release fertiliser when he plants. He feels that this "extra boost" makes the difference between an adequate crop and a bountiful crop. Other growers periodically fertilise with soluble mixes. Some of these soils have to be irrigates during the long summer droughts. If they aren't, the plants won't die, but they will not grow to full size.

Stream Banks and Canal Ditches

These are some of the most convenient areas for growers to plant, since they provide an ample supply of water, which may contain fertiliser runoff. Stream banks are an area that marijuana naturally colonises, and the planter usually needs only to cultivate the area to be sown, and cut surrounding bush so that the young plants can compete with established plants. It the surrounding vegetation looks pale and stunted rather than lush green and vigorous, the soil should be fertilised. These soils are sometimes low in calcium, which dissolves readily in water. Lime should be added to correct for acidity.

Sometimes the ground is a little too wet early in the growing season, although it dries out later on. Planting on hills or mounds is often used to solve this problem.

Arid Areas

Soils which have a low water table and dry out by June or July need to be irrigated to grow marijuana successfully. When irrigation is not feasible, growers plant along drainage ditches, streams, and canals, or look for green spots which indicate springs or underground reservoirs. Other growers use containers to minimise water loss. One grower in Arizona dug holes two feet wide and three feet deep, and lined the sides with thin polyethylene. He said that when he watered during the summer drought, he did not lose much water to the surrounding soil.

Arid soils usually have little organic matter, and drain quickly with extensive runoff. Some of them have a subsurface layer of clay, and therefore hold water on the surface until it evaporates. In any case their texture can be improved greatly by working in organic matter. The soil should be loosened at least two feet down. This loosening allows the taproot to develop deeply so that it can reach underground water during the drought.

Arid soils more often drain well, are alkaline, and contain P, K, and trace elements, but are low in N. Fish meal, cottonseed meal, blood meal, or manure may be the only additive the soil needs.

Chapter 14
PLANTING AND TRANSPLANTING

After the soil is adjusted, you are ready to prepare it for planting the seed. Sowing is an important process, since the post-germination or seedling stage is the most critical for Cannabis. You can increase the seedlings' chance of survival by sowing the seeds properly.

14.2 When to Plant

Most hemp-growing manuals advise that the seeds should be planted about two weeks after the last threat of frost, which is the same time that corn is planted. As a rule of thumb, you need not plant until this time in areas that have a growing season of five months or more. These areas include most of the United States, except for Zone One (see Figure 62) and mountainous areas of the country.

Growers in northern areas report that plant have survived light evening frosts with little or no damage. We think of marijuana as a tropical plant, experiencing no chills in its native climes. But the mountainous areas of marijuana cultivation in Mexico and Colombia often have frosts during the growing season. One grower, describing spring (April) conditions in Nebraska, reported "plants (from tropical seed) three and four inches tall were covered with snow in the evening. By midafternoon all the snow had melted, and those little sprouts were healthy as could be."

Early-season sprouts do face more risks than later-germinating plants do. A lingering freeze or chill can weaken or kill them. Sometimes seeds or seedlings get washed away be heavy rains or flooding, or become infected from wet soil. They are also prey to hungry herbivores, who savour the tender young shoots, especially in the early spring, before the native plants have sprouted. These predators include rabbits, groundhogs, rats, mice, and possibly squirrels and cats, as well as large animals, such as deer, cattle, and sheep. Birds frequently eat the seeds and young shoots, especially if the ground looks planted. Snails and insects, such as cutworms and leafhoppers, also eat seedlings. Don't let this impressive list of dangers dim your enthusiasm. Although these problems do occur, they can be controlled or prevented with a little but of planning (see section 16). {Figure 62. Average date of last expected spring frost for US.}

As you can see in the Spring Thaw map (Figure 62), the last date of expected frost varies from early

February in parts of Florida, Louisiana, Texas, California, and Nevada to mid-June in the coldest regions of New England and the Midwest. Planting time varies locally, as well as regionally. Fields which receive direct sun warm faster than partially shaded ones. Fields covered with a layer of compost or fresh manure, or with black plastic sheets, retain more heat and are ready to plant sooner than other fields. Mountainous areas often vary considerably in planting time. Higher ground usually stays cold longer than low-lying areas. Since soil is dark, it heats quickly when exposed to sunlight. Soil is usually warmer in the late afternoon.

The time that the soil warms also depends on the weather. During severe winters, a deeper layer of soil becomes frozen than during mild winters; so it will take longer to thaw. Soil below this layer is insulated by the ice and remains unfrozen. Spring weather, rainfall, flooding, and cloud cover also affect the soil's temperature.

Actually, the only way to know whether or not a field is ready to plant is to feel it and look at it. Examine the soil in early morning. It should be easy to work, rather than hardened from ice. There should be no large frozen clods of soil or other organic matter. There should also be no fine crystalline ice particles which glimmer in sunlight.

For fall harvest, sow outdoors after March 21, the first day of spring and the turn of the Equinox, when there are equal lengths of sun-up and sun-down. There are an additional 20 to 30 minutes of light before dawn and after sunset, for a total of 13 hours of daylight. When plants are started earlier, they may flower prematurely because of the short days. The plants may also be subject to sex reversal, and more males may develop.

There is little advantage to starting Cannabis before April. Each plant has a certain genetically defined potential for growth and size. As long as the plants have enough time to grow and develop, usually five or six months, this potential is realised (some Colombian and Asian varieties may need longer to develop). Plants started before spring grow no larger in size than plants started during April. The younger plants are virtually indistinguishable from the older ones by harvest, and plants which are started earlier face more risks of detection and destruction. {Figure 63. Average date of earliest expected fall frosts for the US. Information about Australia can be found in an Atlas.}

However, if you are faced with a short growing season, you can get a head start by germinating the seeds a week to six weeks before the local planting time, and transplanting the seedlings outdoors at about the same time seeds would be planted in your area. You can also hasten planting time by covering the area to be sown or planted with a clear (or black) plastic sheet, which will warm the ground by the greenhouse effect.

14.3 Preparing to Sow

Growers sue three basic techniques to sow marijuana: rows, hills, and broadcast. Each method is suitable within a certain range of conditions and has its own advantages and disadvantages.

Rows

Rows are convenient to use, especially for large areas. They are constructed easily using a how, plough, or tiller.

Rows facilitate the care of gardens and fields by setting up an organised space in which the plants and surrounding area can be reached easily by the gardener. Weeding, watering, thinning, pruning, and harvesting can be accomplished very quickly. Larger fields are planted in roes to accommodate ploughs, planters, and cultivators. They are essential when fields are flood-irrigated. Furthermore, they provide a way to use space in the most efficient possible manner. But rows make detection easier, since they have an orderliness that plants do not exhibit in nature.

On sloping and hilly ground rows are a major factor in soil conservation: such soil is easily carried away in windstorms and in the runoff after rain. For this reason, rows on hilly and sloping ground are contoured:

curved to run perpendicular to the slope.

Space rows two to six feet apart; plant seeds every four to eight inches ((In any description of planting which we give, we refer to 100 percent viable seeds. In this case, for example, if seeds are tested (see section 3) and have a viability of 50 percent, sow the seeds two to four inches apart. If they have a viability of 33 percent, sow them one to two inches apart.)) (See Box H.)

To construct a row, break up any large clods on the surface of the soil. In a garden-size area this is easily done by striking them with the tongs of a rake. In larger areas a tiller or externally powered cultivator can be used. Then level the soil.

If you need to irrigate or have problems with excessive moisture, use a hoe to raise the soil in alternate rows of hills and trenches. Pat the crests of the hills with the hoe or a shovel so that they are an inch or wider at the top, and four to eight inches high than the trenches.

BOX H Plant Size and Spacing

Plants vary tremendously in size and branching habits because of many factors, including variety, soil fertility, length of growing season, amount of light received by the plant, water, spacing, and pruning. As a result, one can have no firm rule about how far apart plants should be spaced.

An individual full-grown plant may have a diameter at its base as wide as ten feet or as small as 18 inches. Most conical-shaped varieties (Colombian and Jamaican) grow between seven and 12 feet tall, and have a width between four and six feet. Mexican plants are somewhat taller and thinner, with a base diameter of three to five feet. Some exotic Indian, Central Asian, and Central African plants may have a diameter only one or two feet across. The descriptions are generalisations; there are many varieties within each country, and much variation within each variety.

Pruned plants have a much wider base than unpruned ones. Plants pruned at the fourth internode and again a month later sometimes grow twice as wide as an unpruned plant.

In order to catch as much sun as possible, rows should be orientated along a north-south axis, perpendicular to the course of the sun. The advantage of lush rows is more pronounced in southern than northern latitudes, but the solar-energy differential in north-south versus east-west rows is significant at all latitudes in the United States, and becomes more important on steep slops. Another factor is the orientation of the garden as a whole. Plants sown in a square plot whose sides point northeast and southeast get about 10 percent more light than ones in a plot whose sides point due north and due east.

Hills

Hills and mounds are especially convenient for small plots. Low hills are often camouflaged to look like natural or wild stands, and are very useful in areas in which the land is too wet in the spring, because the hills drain above the ground level. They are easily adapted to meet unusual requirements. For example, a grower in New Mexico planted a doughnut-shaped hill eight feet in diameter and two feet thick, leaving a centre hole four feet in diameter. He placed a portable plastic tub in the hole after punching pinholes around the edges. To water he just filled the tub. In the swampy Everglades, two industrious farmers constructed a giant hill-row three feet thick and three feet high. The hill had such a good drainage that it kept the plant roots well-drained even during the rainy season.

Hills are usually constructed between two and five feet in diameter. Small hills are usually planted with 15 to 20 seeds, and large ones may be sown with as many as a hundred. The hills are spaced three to 10 feet apart, so that each groups of plants gets a maximum amount of light. Hills can grow more than you would at first suspect. For instance, if you were to grow a hill three by three feet, you could harvest six to nine large plants. Their foliage would extend two and a half feet beyond the hill, for a total of about thirty square feet of foliage space.

Broadcast Seeding

Broadcast seeding is the fastest and easiest way to sow, but is not an efficient way to use seed. Seeds are simply tossed or shaken onto the prepared ground, at the rate of about forty per square foot, and are then usually pressed into the soil with a light roller or by foot. This method is most effective in moist soils. Many of the seeds never germinate or die immediately after germination. The faster growing ones naturally stunt the others by shading them. This method is often used by guerilla farmers who want the stands to look natural and who wish to plant large areas quickly. An experienced grower can sow several acres a day by hand using this method.

Seed Count

There are approximately 2,300 medium-sized seeds in an ounce, or about 85 per gram. An acre is about 43,000 sq. ft., or a square 208 feet on side. To plant an acre in rows two feet apart with a seed every four inches requires about 90,000 seeds or 39 ounces (1,100 grams, or two pounds, seven ounces). At this rate, a ten-by-ten plot requires about 2.5 grams of seed.

A typical hill field has four-foot-wide hills spaced about seven feet apart. A typical hill and surrounding area accounts for approximately 100 square feet. There are approximately 430 hills in an acre. If each of these is planted with 100 seeds, the field requires about 43,000 seeds, which weigh about 18 ounces.

Broadcasting requires a lot more seed. At the rate of 40 seeds per square foot, a grower uses about 2.3 ounces in a ten-by-ten plot. An acre requires about 47 pounds, or 21 kilograms of seed.

How to Plant

Finally, after the soil is adjusted, and the rows or hills are built, it is time to actually plant the seeds and watch your garden begin to grow. If you are growing with clover as a cover or companion plant, dig it up to a depth of four inches and chop up the soil. Water the soil to the point that it feels almost wet. Drill a hole with a seed drill, stick, or pencil, then drop one seed into the hole, cover it gently, and pat the soil down again. Marijuana seeds are large enough to handle individually; so each one can be planted separately.

How deep one digs the holes depends on the kind of soil in which one is planting. Light woodsy or organic soils are planted 1/2 to 3/4 inch deep, so that the stem is held firmly in an upright position. Sands and light loams are planted 1/2 inch deep. Heavy loams and clay are planted 1/4 to 1/2 inch deep, so that the sprout's energy is not expended before it breaks through the soil.

If you are broadcast seeding, you can increase the germination rate tremendously by screening a layer of soil over the seeds to help keep them moist. Seeds that dry out weaken or die.

In a garden that has been mulched, lift away the mulch cover at each place you plant, and sow the seed in the underlying soil.

In soft-textured soils, instead of digging or poking holes, press each seed to the desired depth, and cover or pat the soil smooth.

14.4 Germination

The seeds need constant moisture in order to germinate. Therefore, the ground should be well-watered. Keep the soil moist by watering it with a light spray whenever it begin to feel dry. This may mean watering the immediate area once a day. You can keep the soil moist and hasten germination by covering the planted area with transparent glass or plastic. Most of the seeds should sprout in a period ranging from three days to two weeks. This variation depends on variety, age and condition of seed, and soil temperature; the warmer the soil, the faster the rate of germination.

Once they have germinated, the seedlings should be kept moist until the roots grow deep enough to absorb an adequate supply of water from the subsoil. If the ground is still moist from spring rains, as it is in many of the eastern regions, you may not have to water at all. On the other hand, there are sections of the West which are completely dependent on irrigation.

When the seedlings are only an inch or two tall, you can protect them from heavy rains or frosts by using drinking glasses, jars, or paper or plastic cups. You can protect larger plants with containers from which the bottoms have been removed. Transparent containers warm the soil by the greenhouse effect, capturing light and turning it into heat. In warm weather, use white or translucent containers, which prevent burn by reflecting some light and diffusing the rest. Containers also keep the soil moist, serve as plant markers, and protect the plants from some enemies. A grower in Berkeley, California, used cracked fish tanks to protect plants in the early spring. A guerilla farmer in the Poconos puts up four posts, one at each end of a row. She uses them as a frame for clear polyethylene covering, creating a small greenhouse.

Growers in Zone Five sometimes harvest a spring crop by transplanting indoor-grown, two-month-old plants outdoors right after the last frost date. The naturally short days and long nights trigger the plants into flowering. (See Transplanting below, and the discussion of the photoperiod in section 3.)

If started after May 15, marijuana may not have time to reach its full size or flower. This problem mainly affects growers in Zone One and in mountainous areas. But even if the plants do not grow to full size or flower, you can still harvest a potent crop of preflowering tops, which may be almost as potent as ripe buds. The harvest is not as large as a crop of buds, but it is more than worth the effort.

14.5 Transplanting

Seedlings and young plants are transplanted after the last threat of frost. If the growing season in your area is less than five months, you may want to start the plants indoors, or in cold frames, transplanting when the weather permits. A 10-by-four foot cold frame can easily hold 60 two-month-old plants. The cold frame can be constructed with two-by-two's or branches gathered at the site. Cover the frame with a double layer of six- or eight-mil polyethylene plastic or similar material. Attach the plastic to the frame with tacks or staple-gun tacks. If the area is unprotected from the elements, slant the roof so that rain will run off. If the area is windy, place rocks or branches along the frame to add weight. Orient the cold frame to face the south.

In areas with a growing season of six months or more, plants will not necessarily get larger if they are started earlier than normal. Plants started at normal planting time catch up to the older plants by season's end. It serves no purpose to start plants before about March 21, the spring equinox.

Where there is no threat of frost (in Hawaii, southern Florida, and parts of Texas, Louisiana, and California), growers can raise a winter crop. Grow the plants for two or three months under artificial light. Plant get off to a faster start under artificial lights than natural light during the winter months. Move or transplant them before the beginning of March. Most strains will flower because of the short days (less than 12 hours of light) and fill out to well formed plants by the end of May when they are ripe.

For the normal summer crop, seedlings should be transplanted after the last threat of frost. The best time to transplant is on a rainy or cloudy day, which allows the plants to adjust to the new environment without the strain of intense sunlight. Plants grown in a cold frame or sunny window adjust more easily than plants grown under fluorescent lights. Plants grown under artificial light usually show evidence of shock when they are moved to sunlight. Near sea level they may lose some of their green colour and appear pale or yellowed. At high altitudes, such as mile-high Denver, the leaves may actually burn, turn brown, and fall. Healthy plants usually recover quickly by adjusting the new growth to the changed conditions. However, plant can be conditioned to the new environment by being placed in a partially sunny area, preferably where they are shaded during the middle of the day and receive either morning or late-afternoon sunlight. The plants need about a week to adjust.

Seedlings grown in planting pellets for up to 10 days after germination can be placed directly in the soil. Peat pots should be scored with a knife so that the lateral roots can penetrate the pot more easily. Seedlings started in milk cartons or flower pots should be removed from the container so that the roots are disturbed as little as possible. Plan on using a pot size which is root-bound by the time that you transplant. (For the relationship between pot size and number of weeks, see Table 17.) To transplant, water the area to be transplanted and the plant. Then dig a hole a bit larger than the pot and loosen the

surrounding and underlying soil. Place the plant in the hole, and pack the soil so that the stem base is at the same depth that it was growing at before. Firm the soil and water the area.

In areas where ripoffs are expected, such as parts of Hawaii and California, some guerilla farmers transplant individual plants (one to each site) to sites which are widely spaced over the countryside. In this way they may lose some, but at least not all, of their plants to ripoffs.

Each plant (one to three months old) is transplanted to a cone-shaped hole, two to three feet deep by two feet across the top. This strategy is well-suited to areas with poor soil. Since much of the hole is taken up by rootbound soil, it is easy to gather enough topsoil and sand to fill the hole. The gathered soil should also be mixed with organic or slow-release fertilisers which provide ample N and P.

Chapter 15
CARING FOR THE GROWING PLANTS

15.2 Weeding

Marijuana is a fast-growing annual whose survival depends on its ability to compete with other fast-growing weeds. At the end of each season, plants growing in a wild stand may cover the ground with thousands of seeds per square foot. Many of these are relocated by wind, runoff, and birds, and some are destroyed or die. Other never receive the conditions they need to germinate; and of those that do germinate, many die as seedling. The remaining plants compete with each other and with other weeds for the available light, nutrients, and water. Even so, wild stands may be as dense as forty plants per square foot. In order to survive the competition, Cannabis expends a great deal of its energy during the first two month growing a main shoot which is taller than the surrounding vegetation. Then it develops lateral branches which shades the shorter plants. With their source of energy - light - cut off, the shaded plants stop growing and often die.

When you cultivate - that is, eliminate weeds - the rate of germination and survival of your plants is increased enormously. Growers using clover, sheet composting, or mulch as ground cover can expect very little interference from weeds during seedling development. But plots of fertile, aerated, and cleared soil are open to colonisation by a wide range of plants; so you may have to weed several times before the marijuana's dominance is assured.

When you weed, make sure not to pull out any weed seedlings which may have roots in the same area as the Cannabis roots. Instead, cut the weeds slightly below the surface with a cliperr, scissors, or your fingernails. Weeds more than six inches away can be safely pulled. Leave them to dry right on the soil. As they dry and decay, they return the soil's nutrient to it.

Growers plagued with weeds can cover the soil with mulch, paper, or polyethylene sheets. One grower found that two computer sheets fit exactly between the rows. Another used torn drapes as a temporary ground cover.

Once Cannabis has established dominance over an area, the other weeds are not able to interfere with its growth. But if there is wide spacing between the plants, the weeds may have open space and start to grow rapidly. Keep these weeds clipped short if water or nutrients are scarce.

15.3 Watering

Marijuana requires an ample supply of water to live and grow. The actual quantities that it needs depend on the plant's size, the gardening techniques, type of soil, temperature, wind, humidity, and intensity of light. A vigorous plant may transpire several gallons of water a day during the hot summer months. If it receives less water then it need, it stops growing, wilts, and then dries out. {Figure 66 Areas with less

than 30 inches of rain usually require some irrigation.}

Seedlings

Marijuana germinates best in a moist soil. Within a week, it grows a taproot three or four inches long. By the end of the first month, the root system may stretch over an area a foot and a half in diameter and go more than one foot down. Until then, the soil should not be allowed to dry out. Plants which have germinated during warm, sunny weather may need to be watered until the roots have grown deep enough to reach sub-soil moisture. When the soil three inches below the surface feels dry, seedlings should be watered, preferably by using a watering can or the spray setting on a hose. Gently water the soil, making sure not to disturb the seedlings or the soil surrounding. The soil should be thoroughly saturated so the moisture percolates down, encouraging the roots to grow deep. If the surface is only lightly watered, the roots may grow near the surface, leading to water problems as the soil gets drier during the summer.

After the first month, Cannabis does best when the soil goes through alternating moist and dry periods. This alternation allows the lateral roots to come into contact with air. By the end of the growing season, the root system may penetrate the soil to a depth of six feet or more. As long as they are not blocked by solid rock or dense clay, the roots grow by following a trail of moisture. If the trail leads deep, the roots follow. The deeper layers of soil are less likely to dry out during hot, dry weather.

Older Plants

As a rule of thumb, Cannabis over a month old should be watered when the soil about six inches deep feels dry. But this rule provides only a rough indication that the plants need water, because there may be deeper sources of water that are not apparent. The most obvious indication of a problem is wilting. A more subtle one is slow growth during the (ordinarily fast-growing) vegetative stage.

Since you want to wet the lower layers, you should thoroughly saturate the soil. If the soil is completely saturated, it should hold water for a minimum of a week. Usually only two or three waterings a month are required by a garden that is completely dependent on irrigation.

The most efficient way to water is to let the water slowly seep into the soil, so that all the organic particles which hold the water are saturated. If the soil is very dry, and the water beads or runs off and is not absorbed, add household laundry detergent at the rate of one or two grams per gallon of water. It acts as a wetting agent, which breaks the surface tension. Once the soil is treated with a wetting agent, it usually absorbs water throughout the growing season.

In drier areas where corn. cotton, and other deep-rooted crops are irrigated, marijuana also requires an additional source of water. But in areas where there are patches of wild hemp or where deep-rooted crops grow by using available ground water, marijuana does not need to be watered, although additional water may increase its growth.

Box I
Water in General

Deep soil layers retain water much longer than the top layers. To encourage the development of a deep root system, saturate the ground when you water. The roots follow the moisture trail.

Water conditions also vary from field to field. For instance, many mid-western farmers plant along the banks of meandering streams. Even in dry areas, these plants have a natural source of water. Mountainous areas are usually well-drained and dry out before valleys do. Low-lying fields remain moist later, and are saturated by runoff from higher ground. In browned areas, farmers look for green spots which indicate underground streams, springs or runoff. Planters look for deserted wells or active watermains with leaks. Fields high in organic matter retain moisture longer than other fields, and mulching may cut water evaporation by 50 percent.

Watering Techniques

Gardeners may supply water by using a bucket, can, or water-hose. But growers with larger plots often rely on waterpumps to deliver river, lake, or well water to their gardens. Irrigation canals, drainage pipes and ditches, and water mains are sometimes convenient sources of water. The two most efficient methods of watering are the drip hose, which seeps water around the plant, and hand watering into an enclosed area around the plant's stem.

There are several kinds of drip hoses. Some have perforations every three to six inches along their length. These are useful when marijuana is planted in rows or large hills. Another kind is actually a kit, consisting of a main feeder hose and several side hoses two to four feet long. Each side hose has a metal bulb at the end which can be adjusted to regulate water flow. The bulb lies near the plant stem. A drip bottle was invented by a grower in the dry area of Nebraska who was only growing a few plants. He punched pinholes in the bottom of several one-gallon milk jugs and placed a jug near each plant. The jugs slowly watered the garden. Every few days, he refilled the jugs from a nearby irrigation ditch. As the plants grew larger, he placed more jugs around them. The drip method moistens the soil slowly, but does not flood it; so the soil and its nutrients are not washed away. Since this method allows you to decide exactly where the water goes you need not waste any on non-productive land.

Growers sometimes use elaborate setups, such as battery-electric, hand- or foot-powered, ram- or windmill-driven pumps. Foot-powered pumps are probably the most convenient for small plots. They are extremely lightweight (just a little heavier than a bicycle), inexpensive, easy to construct and disassemble, and virtually silent. Since you have much more power in your legs than in your arms, foot-powered pumps con do more work, and do it faster, than hand-powered pumps.

Electric pumps are relatively quiet and pump and enormous amount for their small size. But they require a source of electricity. They cannot be used unless there is a power line available, although there are car alternators available which produce 110-volt current.

Gasoline pumps and electric generators are heavy and noisy. Even with a muffler, they can be heard for miles in some country areas. They require a source of fuel, and often an elaborate setup, including rigid feed tubing, fuel tank, and platform. But once they are in place, the can deliver a tremendous amount of water. They are usually used by farmers growing large plots. Sometimes growers dig a hole in which they store and run the equipment. This setup helps muffle the sound and keeps the machinery in good working order.

Ram- and windmill-powered pumps use running-water and wind energy, respectively. They come in many sizes and are often used to fill water tanks for later use. They can also be used to generate electricity to run electric pumps. They require no fuel, are usually silent, and can be constructed inexpensively.

But some farmers have devised other methods for getting water to their plants.

A farmer growing near Tucson, Arizona, trucks water to her plants twice a week using a pickup truck and four 55-gallon barrels. She attaches a garden hose to her tanks, and siphons the water to her garden, 200 feet downhill.

Two foresighted farmers in Texas carried twenty 30-gallon plastic trash cans and lids to their garden. During the spring rains, they filled the containers from nearby gullies. By the end of the rainy season, the had collected enough water to carry them through the summer drought.

A homesteader in Oregon's dry eastern section dammed a gully by using and earth stabiliser, plastic, wood and cement, and pipe. During the winter his private reservoir filled.

Farmers near Atlanta tapped into a city water main. The pressure from the water main allowed them to pipe water uphill.

15.4 Thinning

If the soil is kept moist during germination, most of the viable seeds that you planted will germinate and

the seedlings will soon start to crowd each other. This happens frequently when the plants grow on their own. Then they grow into a dense hedge-like mass dominated by a few plant. The dominant plants typically have long internodes and a long sturdy stem with little branching. The shorter, bushier plants are shaded by the taller ones and become stunted from the lack of light. By thinning, you give the plants that are left enough room to grow to their full potential, and you choose the ones that you think will grow to be the best for smoking. Leave the plants that have dense foliage, are branching, and, later in the season, the ones that are the most potent.

Thin the plants as soon as they begin to touch or crowd each other. This should be repeated as often as necessary. Seeds sown six inches apart in rows two feet wide require thinning several times during the season. But guerilla farmers sometimes let the plants compete so that the garden looks more like a wild stand.

There are two methods used to thin: cutting the stem at the base so that the entire plant is destroyed, and cutting just the tops so that the plant's growth is thwarted, and the uncut plants shade it. The cut plants remain relatively inactive, and do not use much water or nutrients, but they do shade the ground and use otherwise wasted space.

15.5 Staking

Outdoor-grown plants rarely need staking. When the stem bends from the wind or rain, tiny tears in the structure develop. These are quickly mended by the plant: it grows new cells which increase the girth of the stem and make it stronger. But plants which are suffering from nutrient deficiencies or are top-heavy because of competition may need to be staked. Heavy rain sometimes cause the plants to fall over, especially if they have shallow root systems which cannot hold the added weight.

To stake, drive a sturdy rod six inches from the stem and deep enough into the ground to be able to give the plant support. Then tie the stem to the stake with wirer twists or string.

If the stem or the branch is cracked, pinched, or bent at the base, its position should be corrected and held firmly with a splint. The splint can be held with masking tape. In a few days the plant grows tissue to support the damaged area.

15.6 Pruning

Growers prune (clip or top) their plants to increase productivity, prevent detection, or to harvest early smoke. In the near future, new laws will decriminalise or legalise marijuana cultivation. These laws will probably limit legal cultivation either by the total gardening area or by the number of plants an individual or group may cultivate. Gardeners limited by space will maximise yield by cultivating a dense stand of tall, unclipped marijuana. Growers permitted to grow only a few plants will grow the largest, most productive plants possible. This is done by giving the plants the best possible growing conditions and a lot of space between plants to maximise light and minimise competition for water and nutrients.

Unpruned marijuana develops in one of three classic shapes, depending on variety. Many Mexican and Thai varieties develop into a tall, narrow bush no wider then three feet and shaped like a poplar tree. Colombian, Cambodian, Indian, and some south Mexican and Vietnamese varieties are Christmas-tree shaped. Some Moroccan and Afghani varieties have complex branching and naturally grow into small, dense bushes, about five feet tall. Marijuana usually grows to its full height by early September. Most of the marijuana plants you are likely to cultivate will grow to between eight and fifteen feet tall. Some Hawaiian and Thai varieties average between twelve and twenty feet tall.

Increasing Yield

When marijuana is clipped to increase the number of growing shoots, the total yield at season's end may not be increased. Provided that soil and water are not limiting to growth, each plant can reach a maximum size when given enough room. The more surface are the plant presents to light, the closer it will get to its maximum potential. Where the plants are grown with much space between them, clipped plants can yield

more than unclipped plants, especially if the branches are spread out to maximise the light on the plant. When the plants are grown close together, the taller a plant is, the more sunlight it will receive, and hence the larger the possible yield.

Some growers prefer to harvest a top stem that is thick with buds (colas). The largest colas form on the main growing shoot of unclipped plants. When the growing shoot is clipped from a plant, the new shoots and leaves grow slower and smaller than the main shoot of an unpruned plant because the capacity for growth is spread out over several shoots. When a plant is clipped early in the season, most of the difference in lead and bud size is made up by harvest time.

Marijuana can be pruned at any time during the seedling or vegetative growth stage, but you should prune plants when they are young if you plan on harvesting growing shoots during the season. A seedling clipped anywhere from the fourth to sixth node will usually form at least six strong growing shoots that can be harvested during the third or fourth month. If these shoots are cut again while the plant is still young, marijuana often develops into a small, very compact, hedge-like bush.

Yield can be increased by spreading the plant's branches so that more light reaches the inner growth. Cannabis stems are bent most easily when they are still green and fleshy, nearer to the new growth, but the whole plant can be bent to form a gentle arch with the top of the main stem in a horizontal position. Within a few days the side branches along the top will begin to grow vertically, competing with the main stem. They will soon develop their own horizontal side branches. To bend a plant, tie the main stem loosely with a cloth or heavy string. Tie the other end of string to a heavy weight or anchor on the ground. Don't put too much pressure on the stem as this tears some of the roots and weakens the plant. You can bend the plant a little each day until the plant is in the desired position.

You may also increase yield by bending only the growing tip. This encourage the side branches to develop sooner than they naturally would. Only the flexible part (about the last foot) is bent. To bend the top, use stiff wire or wire twists used for plastic bags and wrapping vegetables. Fasten the other end of the wire lower in the stem to hold the tip in position. {(See Figure 49.)}

A common mistake that cultivators make is pulling off the large leaves on the main stem (sun or fan leaves), when the plants are young. These leaves are removed by cultivators who believe that their removal will cause the undeveloped side shoots to grow. But fan leaves are net producers of sugar and energy, which are used by the side soots to begin growth. Rather than encouraging new growth, the removal of fan leaves slows growth. The plant will also be more susceptible to attacks from pests and predators.

When the plant is several weeks old and growing well, the difference between plants with their leaves removed and those left intact may not be large. The biggest difference can be seen when leaves are removed from branches just prior to, or during, flowering. The buds that form from leaf axils with leaves removed are noticeably smaller than those where the leaves have been left on the branch.

Detection

Cannabis can be detected from both the ground and the air. From the ground, marijuana is revealed by its familiar shape, unmistakable leaves, and odour. Tall plants are usually more conspicuous than shorter ones. From the air, stands may have a different colour than the surrounding vegetation, especially where natural vegetation is not as lush as marijuana. Individual plants usually have a circular profile when viewed from above; this can be altered by bending or pruning the plant. Varieties which are naturally tall-growing may need to be cut several times during the season to keep them hidden.

Plants are sometimes cut back severely, to much as half their height when they get too tall, but this may damage the plant. A less drastic topping technique is to remove the opt foot of growth. Whenever new shoots get too tall they are clipped. But the plants should not be severely pruned late in the season when the growth rate has slowed (preflowering), because there will be fewer branches left on which buds can develop.

If you are trying to conceal plants behind a fence or wall, start bending or pruning the plants early, at about one month of age. By starting early and continuing to prune during the vegetative growth stage, you will train the plant to branch and fill up the area. If you wait until the plants are already tall, you may have to cut the plants back severely or clip shoots continuously.

15.7 Gardening Tips

Transplant Older Plants

A friend of ours was warned that his garden had been spotted by local authorities. Rather than cut down his four-month-old plants, he decided to transplant them. He dug the plants out, leaving a ball of soil about two feet square around the roots of each one. He wrapped each soil ball tightly in a plastic bag to transport it, and placed the plants in newly dug holes in a different spot. He kept the plants well-watered. After a few days, they recovered from transplant shock and started to grow once again. Transplanting large plants is not easy to do, but it could save a crop. The marijuana root system is not very extensive when the plants are in fertile soil with plenty of water; the tap root may only be six inches long on a ten-foot plant.

Wind Protection

Hemp Cannabis planted closely together has been used by farmers to form a windbreak to protect other crops. If you are growing in an especially windy area such as the Midwest, you may wish to plant a perimeter if tightly spaced Cannabis to protect your garden. Construct a rope and stick fence against the windbreak to hold the plants upright and prevent them from falling into the central garden. Simply keeping the plants clipped short is a simpler approach.

Inducing Flowering

Growers may wish to induce their plants to flower early, especially in the North, where the growing season is short. Plants in containers can be moved to a dark area for 12 hours of darkness or more per day. Black sheets of polyethylene film, dark plastic bags, and large appliance cartons can be used to provide periods of uninterrupted darkness. Use the dark treatment nightly until the plants are flowering (usually after one to two weeks of long-night treatments).

Winter and Spring Crops

In southern parts of the U.S., Hawaii and parts of California, you can grow more than one crop in a season. Greenhouses that stay above freezing can also be used for year-round growing. Plants started during the winter or early spring get naturally long nights and flower early, when they are relatively small, usually no more than four feet tall. Flowering can be postponed by breaking the long nights with short periods of light. This extends the vegetative growth period, yielding older, larger plants at flowering. Start breaking the night period with artificial light when the plant is about a month old. Continue the treatment until you want the plants to flowers. (See the discussion of photoperiod in section 3.)

Spring crops can be trimmed of buds when mature. The plant is left in the ground, and as the daylength increases, the plant will renew vegetative growth and flower once more in the fall. Plants can also be started in November or December indoors under lights and planted outdoors in February for harvest in April or May. The plants will grow faster under lights than they would outdoors under the weak winter sun. When they are placed outdoors, the long nights will induce flowering. By April the sunlight gets much stronger, perfect for flower development. Plants placed outdoors in February adjust easily to sunlight. Even so, they should be conditioned so that they do not suffer severe burn, as described in the Transplanting section in section 14.

Rejuvenation

Plants grown in areas where the weather is mild can survive winter when there are no heavy freezes. During the winter the plants will grow very slowly, but as soon as the weather warms, and the light gets

more intense, the plants respond. This technique can also be used to obtain a second growth crop during Indian summers. The second growth is not as vigorous as the original, but is does increase the total harvest.

To prepare plants for rejuvenation, leave three or four pairs of lowers branches with leaves on the plant when you harvest. The leaves need not be large, but they must be green. Water and fertilise the plants. Within a few days the plants will show new growth.

The authors observed an outdoor container composed entirely of plants which survived a mild San Francisco Bay Area winter. These developed healthy second growth the following summer and flowered again in the fall. Some growers in Hawaii claim that their plants are three years old and that the plants have yielded as many as six crops of buds. Perennial marijuana plants also grow in Jamaica and Thailand.

Water Deprivation

Many cultivators begin to limit the amount of water their plants receive as soon as the flowers start to appear. Other growers give their plants as little water as possible after the middle of the plant's life. The plants are given small amounts of water only when they begin to wilt. (See section 9 on the reasons for stressing the plants.)

Under water stress many of the leaves may die and fall from the plant. Sometimes the plants appear "burned," and turn brown or gold. At harvest, water-stressed plants may only have buds left on them and these may have the colour, resin, and harshness typical of Colombian grass. These plants yield less grass at season's end. Not only are they smaller overall, but many of the leaves will have fallen away.

Water stress can be difficult to control in areas with heavy summer rain. Water-stressed plants often make up for their smaller size by a raped burst of growth after a heavy rain. One method of control is to cover the ground with plastic sheets when it rains so that most of the water runs off.

Tacks and Nails

Some growers hammer nails or tacks into the stems of plants several weeks before harvest. Many growers use long thick nails; others prefer to use several half-inch-long tacks. The nails are usually placed at the base of the stem. This is supposed to "increase potency." {Figure 72. Wilted plant. Unless watered it will die.}

Stem Splitting

This is a popular way to stress used by cultivators in the United States. The stem is split (not cut) at the base to from a space through the stem. Growers place a rock, small piece of wood, an old Cannabis stem, or piece of opium (in Africa) in the split. Sometimes the wound is bound with cloth or plastic. We don't recommend this procedure, and advise you to be careful not to kill the plants and ruin the harvest.

Varieties

Outdoor growers are well-advised to plant several varieties of marijuana, because some varieties adapt to their new environment better than others. Also, each variety (and to small extent, each plant) has its own bouquet. By planting several varieties, cultivators assure themselves a varied selection of smoking material.

In areas with short growing seasons, many tropical varieties do not have a chance to flower. But immature material from these varieties may be more potent than mature flowers of a plant grown from seed of lower-quality grass. For instance, compare a flowering Mexican with a Colombian that doesn't. The Colombian may be better because the difference in varieties is so great. On the other hand, the Mexican may be better because it is flowering and has reached its full potential.

Intercropping

It is well-known that certain plants may be antagonistic to other species of plants, and that there are also beneficial relationships between species. Cannabis is known not to grow well among spinach 222. Although tomatoes and tobacco have been recommended as crops to avoid when growing marijuana, because of pests and diseases that these plants may harbor 67, marijuana grows very well in healthy tomato patches. Growers have also commented on how well marijuana grows when planted with corn, sugarcane, and beets.

Chapter 16
INSECTS AND OTHER PESTS

Outdoors, where it functions as part of an ecological system, marijuana is less susceptible to insect attacks than it is indoors. In an outdoor environment, insects are subject to the vagaries of the weather, food supply, and predators. And marijuana grows so fast that insects usually do little damage. Plants, plant eaters, and predators usually maintain an equilibrium which minimises damage. But this balance is disturbed by tilling and gardening, and may take a while to re-establish itself.

The soil surrounding your plants may be teeming with insects, and it would be unnatural not to see some on your plants. Most insects do not eat marijuana. The few that do are the food which helps to keep a small population of their predators alive. Insects in the garden need to be controlled only when there is a real threat of damage.

Marijuana is most vulnerable in its early stages. After the plant increases production of the cannabinoids and resins at the eighth or ninth week, most insects are repelled. When the plants are small, an occasional munch affects a relatively larger part of the plant. That same bite affects a relatively smaller part when the plant is larger.

The insects that infect marijuana indoors - aphids, mealy bugs, mites, and whiteflies - do best in humid conditions with constantly warm temperatures. Outdoors they rarely inflict much damage on marijuana. The pests that are most likely to damage marijuana are leafhoppers, treehoppers, cucumber beetles, thrips, flea beetles, several kinds of caterpillars, snails, and slugs. The younger the plants are, the more susceptible they are to attack. Your prime goal is to protect the plants during the first two vulnerable months. You need to keep the pest population low, so that the damage is relatively light. The pests don't have to be eliminated, only kept under control.

There are many ways to keep pests from damaging your crops. These fall into one or more of several categories: biological control; capture traps and barriers; home remedies; and chemical insecticides.

16.2 Biological Control

The theory behind biological controls is that methods for control of pests can be found within nature. These methods are safer to humans and less damaging to the environment than commercial insecticides. Gardeners have many forms of biological control at their disposal, including companion planting, use of predators, and sprays made from plant extracts or ground-up insects.

Companion Planting

Some plants, including marijuana in its later stages, produce resins or essences which repel or kill plant pests. Some of them are general repellents that affect a broad range of plant pests; others affect specific species. Generally, the heavily scented plants, such as spices, mints, and other herbs, are most likely to have these qualities.

Some of the more familiar plants used to protect gardens are the Alliums, or onion family, with garlic, chives, green onions, and other oniony-type plants as members. This group repels a broad range of plant pests such as aphids, spider mites, flea beetles, potato bugs, bean beetles, and many other insects, as

well as rabbits and some deer. They are easily planted around the garden or between the marijuana plants. Just plant onion bulbs or the cloves from a garlic bulb so that the top of the bulb is about one inch deep. One garlic bulb yields quite a few cloves; so a large garden requires only a few bulbs.

Geraniums are reputed to repel leafhoppers and many kinds of beetles. These plants prefer a dry soil, thrive in full light, and usually grow two feet tall. Geraniums should be interspersed with the marijuana, or potted geraniums can be set out if problems develop. Tansy (Tanaetum vulgare) is a tall, fragrant, woody perennial which grows five feet tall. It protects against cut-worms, beetles, cucumber beetles, and other eaters and borers.

Mints repel many insects and are sometimes used as mouse repellents. They are especially useful for the control of the flea beetle. They thrive in semi-shaded areas with rich soil.

Marigolds can be planted to eliminate nematodes. They are fast-growing annual plants which flower profusely. They come in many varieties, ranging in height from six to 30 inches. They grow in a wide range of soils and do best in the sun. The scented varieties - usually nonhybrids - offer the most protection.

All companion plants must be planted close to the plants to be protected, since their repellent qualities spread only a short distance beyond their circumference. They are effective when they are planted before the damage is apparent, and offer long-tern protection. They are used when a pest is expected. For instance, growers in the San Francisco Bay Area expect rose leafhoppers to attack their plants. Since geraniums grow in the area as perennial plants, some growers plant them permanently in the garden. As the geraniums develop into small bushes, the hoppers leave, never to return.

Predators

Many of the insects in your garden are called beneficials, because they perform a useful service in the garden. Some of them eat decaying matter; others help in the pollination process; and some pry on insects which damage crops. Almost everyone is familiar with the ladybug, which eats aphids and insect eggs and has a voracious appetite. They are available commercially by the pint. The praying mantis eats slow-moving insects. When it first hatches, it starts out on aphids and mites. But as it grows larger, it eats bigger insects and worms. Mantis-egg cases are foam-like, straw-coloured masses which contain 100 to 300 eggs. These cases are sold commercially but can also be found in the late fall in bushy areas. Another insect which is sold commercially as a plant protector is the green or brown lacewing. It has golden eyes, looks fragile, and flies erratically. But in their larval state, lacewings eat thrips, mites, caterpillar eggs, scale, leafhopper nymphs, aphids, and mealybugs. The trichogamma wasp is an egg parasite which lays its eggs in the eggs of over 200 species of insects, including many moths and butterflies which hatch into worm pests. Cryptolaemus is used to destroy mealybugs. Adults are released when mealybugs appear in the spring. They seek out the mealybug colonies and lay their eggs. When the eggs hatch the larvae wander around the infested area and eat the young mealybugs.

The use of commercially bred or gathered predators is most feasible in large gardens or fields. The insects may not have much effect on small gardens, since they wander off to find food and may never return. Try to buy from manufacturers who intentionally do not feed their product before shipping. Hungry predators are more likely to stay and eat the pests.

Insects are just one groups of predators. Birds such as purple martins, robins, blue jays, chickadees, and even starlings and English sparrows eat large quantities of insects and other small pests. They can be attracted to the garden by placing a feeder, bird houses, and water in the area. When plants get larger, some gardeners let chickens, ducks, or geese run through the garden. In a short time, they pick it clean of pests and weeds. Reptiles and amphibians, including frogs, toads, snakes, lizards, and turtles, all eat garden pests and should be encouraged to make a home in the garden.

Homemade Repellents and Insecticides

Another way to control garden pests is to make sprays from plants which repel insects by using a juicer or

blender or by baking a tea. Ingredients can be found in most kitchens. Chile pepper, garlic, coffee, horseradish, radish, geranium, and tobacco are the usual mainstays of herbal sprays, although most strong-smelling herbs and spices have some repellent qualities. Many gardeners experiment to see what works in their garden. For instance, if an insect which bother marijuana stays clear of a nearby weed, a tea or blended spray made form that plant may control the pest. But try it on only one plant (or part of a plant) first, because the spray may also be harmful to the marijuana.

Garlic is probably the most popular ingredient for general-purpose sprays made from kitchen ingredients. A typical formula is to soak three ounces of chopped or minced garlic in a covered container of mineral oil for a day. Then, slowly add a pint of lukewarm water in which a quarter ounce of real soap (Ivory will do) has been dissolved. Stir and let stand several hours, than strain. Use as a concentrate, adding between 20 to 100 parts water to one part concentrate.

Other recipes call for boiling the garlic or for grinding or juicing it. Some brewers add other spices to the basic formula. One recipe calls for one clove garlic, three cayenne peppers, one onion, a quarts ounce of soap, and sufficient water to blend. Let it sit for three or four days before using, and use one part concentrate to 20 parts water. Homemade tobacco teas are sometimes used as insect sprays. Use one cigarette in a quart of water. Let it brew 24 hours before using.

Snails and slugs are attracted by yeast solutions, which are easily prepared from cooking yeast, sugar, and water. This is also why gardeners have success trapping these leaf munchers in bowls of stale beer. Place deep-sided containers at the soil level. The pests slide in and drown.

Gardeners should not overlook handpicking as a viable method of pest control. The foot or a quick thumb and forefinger can eliminate large numbers of pests and can keep a small garden pest-free. Collect the bugs and drop them in a tin can with some alcohol to kill them. Early morning is the best time to collect pests, since they are slower-moving until the sun warms them.

Snails, slugs, earwigs, and some other insects gather in cool, moist areas during the heat of the day. By providing just such a space in a garden, many of these pests can be located and destroyed. Place pieces of cardboard or boards around the garden; look under them each day.

Home Remedies

Gardeners and farmers have discovered and invented ingenious ways to control insects without harming the environment. Some of the more popular ones are listed here, but there are many more, each suited to a particular situation.

Soap and water is an effective control measure for mealybugs, mites, leafhoppers (nymph stage), leaf miners, and aphids. Simply wash the plants thoroughly with a solution of two tablespoons of soap dissolved in a gallon of water. Rinse the soap off thoroughly. (Some growers feel that the addition of kerosene or alcohol makes the solution more effective, but these can harm the plants and dissolve THC.) This treatment does not eliminate all of the pests, and may need to be repeated weekly, but it does keep them under control.

Sprays are sometimes made from healthy insects, which are caught, ground up, and then sprayed back onto the plants. When the pests come in contact with the spray, they become infected with the pathogen and get sick. This method is very effective, and is considered safe, but it is not easy to capture sick insects. A variation in this technique was described in the October 1976 Organic Gardening and Farming Magazine, in which a spray was made from healthy insects. In a followup article in the May 1977 issue, the authors theorised that any population of insects contains pathogens. If enough insects are collected, some of them are sure to be sick, and they contain enough germs to spread the disease. To make an insect spray, capture about a hundred pests. (Make sure not to include any beneficial insects or the spray may also work against them.) Using a blender, mix them with a cup of spring water, strain, and dilute with enough water to spray your garden.

Whenever making or storing sprays, use a glass container. Metal or plastic ones may react with the

chemicals that the liquids contain.

Another home remedy for the control of mites and aphids is a mixture consisting of a half cup of milk in four cups of wheat flour, added to five gallons of water. When it is sprayed on the undersides of the leaves, it suffocates the insects and then flakes off as it dries.

Some growers use mulches to control insects. Cedar chips repel beetles, moths, mites, and mealybugs. Aluminium foil is used for aphid and thrip control on small plants; the reflected light disorients them and they do not land on the plants. A sprinkling of cream of tartar eliminates ants, and boric acid kills roaches. Sulfur powders, available at nurseries, are used to control mites and fungus infections.

Organic Insecticides

Pyrethrum, rotenone, and ryania are effective insecticides which come as powders (dusts) or sprays. They are concentrated form of naturally occurring plant substances, and are considered harmless to warm-blooded animals when used as directed.

Ryania, which is found in the roots of a tropical shrub, is most effective against chewing insects, worms, and larvae, which it incapacitates, rather than kills.

Rotenone is a general-purpose insecticide with little residual effect; that is, it breaks down soon after application, and is therefore one of the safest insecticides. Two or three dustings during the seedling stages afford protection against most insects and bugs.

Pyrethrum is one of the most powerful natural insecticides, and is effective against a wide range of pests. It is also relatively nontoxic to bees and ladybugs. Pyrethrums are found in the pyrethrum plant as well as in chrysanthemums. They are non-persistent, and in small doses may make the insects sick without killing them. These insecticides are available at many nurseries and may provide the surest, easiest form of protection against serious insect attack.

Barriers and Traps

In gardens and small farms, insects and other pests are sometimes controlled by the use of traps and barriers that prevent them from reaching the marijuana. When the plant are young, they can be protected from cutworms, caterpillars, snails, and slugs by a collar that is buried an inch into the ground and is six inches high. Some growers face it with aluminium foil, which many insects seem to dislike. One ingenious grower painted collars with molasses to capture the crawlers. She also caught a significant number of leafhoppers. Commercial stickums such as Tanglefoot can also be used to trap insects.

Snails, slugs, and some crawling insects are repelled by a border perimeter of lime, potash (wood ash), sulfur, sharp sand, or cinders. Place a thin layer, six inches wide, around the perimeter of the garden, or around each plant. Flea beetles and some other flying insects are repelled by wood ashes dusted on the leaves. The powders are water-soluble; so they should be replaced after a heavy rain. Crawling pests sometimes have a hard time reaching plants grown in containers or raised beds.

Flying insects, such as leaf and treehoppers, can be prevented from getting to plants by barriers made from cheesecloth. Other growers place cardboard sticky with glue between plants, and then shake the plants. The cardboard catches a good proportion of them. One innovative grower in Palo Alto, California, placed a furniture crate, with the top cut off and with Tanglefoot spread on the inside, around each of his six plants. He said that by shaking the plants, he eliminated leafhoppers in four days.

16.3 Chemical Insecticides

Insecticides were developed as an easy way to control pests. They have an immediate dramatic effect, but the long-range damage that they do to the entire ecological system is sometimes overlooked. The chlorinated hydrocarbons, such as DDT, DDC, Aldrin, Kelthane, and Dieldrin, were the most dangerous commercial insecticides. They affect warm-blooded animals and are no longer available. (In no case should any of these by used.)

Diazinon, Sevin, and Malathion are three insecticides which are often soil in nurseries to protect vegetable crops. They are considered safe for warm-blooded animals and have a limited residual effect, since they break down in a few days. But these insecticides are not too selective and may kill beneficials as well as pests. Sevin is the most toxic and kills the widest range of insects, including bees.

These chemicals come as sprays, powders, and baits, formulated for specific pests. They should be used only when an intolerable situation has developed. Plants should be harvested only after the required safety period has passed since application. This period is from two to 35 days, and is specifically listed on all insecticides that can be safely used. Insecticides should be used and handled carefully, following instructions, wearing protective clothing, with no children or pets around. It is advisable to use a mask when applying dusts and to work upwind.

16.4 Common Pests

Cucumber Beetles

Cucumber beetles are about a quarter-inch long and look a lot like ladybugs. There are several species of cucumber beetles. The striped beetle is found east of the Rocky Mountains. It is yellow, has two or three black stripes running down its back, and has a black head. The spotted cucumber beetle has a yellow-green back with 11 or 12 black spots and a black head. There are related species, such as the banded cucumber beetle, throughout the United States. The larvae of all varieties are white, turning brownish at the ends, slender, about one-third inch long.

Cucumber beetles do the most damage in the early spring, when the adults come out of hibernation and begin to eat the new growth and leaves. These leaf-eating adults damage young marijuana, especially when there is a scarcity of other food. They also transmit bacterial diseases and viruses to the plants. Within a few weeks after they come out of hibernation, they lay their eggs at the base of plant roots. The larvae of the striped cucumber beetle feed only on melon- and cucumber-type plant roots. The spotted-beetle larvae are fond of corn, and are known as the "Southern cornroot worm" in some places.

The best way to prevent cucumber-beetle attacks is to keep the areas that you plant isolated from corn and melon plantings. Heavy mulching or tilling destroys the pests when they are hibernating. Late plantings minimise damage inflicted by cucumber beetles.

Cucumber beetles can be controlled by use of Rotenone or Malathion. Dust several times during seedling growth. These beetles are also prey to many insects, including the common garden soldier beetle, predator flies, wasps, and nematodes. Hand picking is also an effective control for cucumber beetles.

Thrips

Thrips are slender, yellow or brownish, winged insects about 1/25 inch long. They have fragile wings which keep them aloft while they are blown by the wind. Thrips have a cone-shaped mouthpart, which they use to cut stems in order to suck plant juices. The larvae look like adults, but are smaller and wingless. Most thrips feed on a range of plants, especially onion and other bulbs, and marijuana is at most a marginal part of their diet. A well-cultivated marijuana plant can outgrow and damage that thrips are likely to inflict.

Thrips hibernate in plant debris during the winter and begin sucking in early spring. They lay eggs during warm weather, and can produce a new generation every two weeks. Since thrips eat a varied diet, keeping the garden area clear of weeds is an effective control. Thrips can also be controlled by turning debris under, so that their nesting sites are destroyed.

Thrips can be controlled by use of tobacco sprays. Rotenone, or Malathion. Aluminium-foil mulches are effective thrip repellents. The light reflected from the foil confuses their sense of direction.

Flea Beetles

There are many species of flea beetles. The adults range in size between one-twentieth and one-fifth of

an inch, and are usually black or metallic green or blue. They are called flea beetles because they use their enlarged hind legs to jump like fleas when disturbed. Many flea beetles are host-specific, and probably only a few species munch on marijuana.

Flea beetles hibernate in plant debris. By ploughing the debris under, their hibernation places are eliminated, and there should be few pests the following spring. Flea beetles are repelled by a mixture of equal parts of wood ashes and limestone sprinkled on foliage every few days. Containers of the mixture may also by placed around the plants. Garlic sprays also repel flea beetles. The chemical poisons used specifically for flea beetles are stomach poisons, which break down slowly and may not be safe to inhale. Home remedies are best for flea beetles.

16.5 Vertebrate Pests

Mammals Until it develops a hard fibrous main stem, usually at about two months, the young marijuana plant attracts rodents, including mice, rabbits, moles, squirrels, groundhogs, and rats, as well as raccoons. Cats are probably the best means of rodent control. They stalk small prey, go after any movement, and are active at night, when most of these animals forage. Young plants are often protected from rodents by placing a coffee can with top and bottom removed around each plant. When the plants get bigger, they can be protected from rabbits and other animals with a wire fence three feet in height. A double layer of one-inch chicken wire is most effective. But many animals can climb or burrow; so more ingenious methods are needed to protect the plants. Rodents, especially moles, are repulsed by castor beans and castor oil. A formula that gardeners sometimes use is two parts castor oil, one part detergent, mixed to a consistency of shaving cream in a blender. Use a tablespoon of concentrate per gallon of water. Spray or mist the solution on the plants.

Rabbits shy away from blood, bloodmeal, and tankage. To use, sprinkle the powder around the perimeter of the plot in a band about a foot wide. They can also be mixed into a concentrated solution and applied as a spray. However, the small of blood may attract mongoose or other predators, which dig up the garden in search of flesh. Noise from radios, chimes, and bells deter some animals, and human smalls such as hair and urine may also deter some animals. In dry areas, a half-filled bucket of water is an effective rodent trap. The animals fall in and drown.

Deer seem to go out of their way to munch on tender marijuana leaves, but generally don't bother marijuana after it has grown for a few months. Gardeners and farmers use many ingenious techniques to keep them away from crops. Sturdy fences are the best deterrent. The fences should be about 10 feet high: the bottom five feet should be made up of single strands of wire string at two-foot intervals. The wire strands prevent deer from jumping the fence. Some growers use fresh blood, dried blood, or bloodmeal to deter them, placing it in either powder or liquid form around the perimeter of the garden. Other growers claim that human hair, or manure from predators such as wolves, bears, lions, and even dogs, keeps them out. Lion urine (glans extract) is available commercially, and is said to be an effective deterrent against many animals. {Figure 73. Tin cans protect against cutworms and many other plant eaters.}

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{Figure 74.  Fat rat munching marijuana.}
{Figure 75.  Problem solved; or, never underestimate the power of a peanut.
{Rat caught in mouse trap.}}
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Birds

On the whole, birds are beneficial, rather than harmful, in the garden. Most of the common species, including English sparrows, robins, swallows, wrens, finches, bluejays, bluebirds, and starlings, eat insects and other garden pests as a substantial portion of their diet. The only time that birds may be harmful is during planting, when they sometimes feed on the planted seed. The main culprits seem to be starlings, sparrows, and crows. They can be kept off the planted areas physically, by means of plastic netting or fencing, which is sold commercially for the purpose, or by using scarecrows, aluminium strips, or noise makers. Once the plants have germinated, birds are no longer a threat and should be encouraged to nest in the area, since they are an ideal biological control for plant pests.

Chapter 17
GENETICS AND SEX IN CANNABIS

Sex is an inherited trait in Cannabis, and can be explained in much the same terms as human sexuality can. Like a human being, Cannabis is a diploid organism: its chromosomes come in pairs. Chromosomes are microscopic structures within the cells on which the genes are aligned. Cannabis has 10 pairs of chromosomes (n=10), for a total of 20 chromosomes (2m=20).

One pair of chromosomes carries the primary genes that determine sex. These chromosomes are labelled either X or Y. Male plants have an XY pair of sex chromosomes. Females have XX. Each parent contribute one set of 10 chromosomes, which includes one sex chromosome, to the embryo. The sex chromosome carried by the female ovule can only be X. The one carried by pollen of the male plant may be either X or Y. From the pollen, the embryo has a 50/50 chance of receiving an X, likewise for Y; hance, male and female progeny appear in equal numbers (in humans, the sperm carries either an X or a Y chromosome.)

17.2 Flowering

Male Plant

Under natural light, males usually start to flower from one to four weeks before the females. Where the photoperiod is artificially controlled, as with electric lights, males respond quickly (in about a week) to a change to short photoperiods and usually show flowers sooner than the females.

Male flowers develop quickly, in about one to two weeks on a vigorous plant, not uniformly. Scattered flowers may open a week or more before and after the general flowering, extending the flowering stage to about four weeks.

The flowering stage continues to demonstrate the male's tall, relatively sparse growth. Most of the flowers develop near the top of the plant, well above the shorter females. The immature flower buds first appear at the tips of the main stem and branches. Then tiny branches sprout from the leaf axils, bearing smaller clusters of flowers. The immature male flowers are closed, usually green, and develop in tight clusters of knob-like buds. The main parts of the male flowers are five petal-like sepals which enclose the sexual organs. As each flower matures, the sepals open in a radiating pattern to reveal five pendulous anthers (stamens).

Inside the ovoid, sac-shaped anthers, pollen grains develop. Initially, pollen sifts through two pores near the top of the anther; then, starting from the pores, longitudinal slits slowly open (zipperlike) over the course of a day, releasing pollen to the wind. Once a flower sheds pollen, it shortly dies and falls from the plant. Normally, male plants begin to die one to two weeks after the bulk of their flowers have shed pollen. Healthy males may continue to flower for several more weeks, but secondary growth seldom has the vigour of initial bloom.

Female Plant

The female plant generally starts to flower later than the male, under either natural light or an artificially controlled photoperiod. Female marijuana plants flower when the average daily photoperiod is less then about 12 to 13 hours. However, some varieties and individuals may flower with a photoperiod of over 14 hours. Some Colombian varieties may not respond until the photoperiod falls below 12 hours for a period of up to three weeks.

The duration of flowering also depends on the particular rhythm of the variety, as well as growing conditions, and whether or not the plant is pollinated. Within these variables, females maintain vigorous growth and continue to rapidly form flowers for a period that ranges from 10 days to about eight weeks.

Females generally do not grow much taller during flowering. Growth emphasises a "filling out," as flower clusters develop from each leaf axil and growing tip. Normally, the flowers arise in pairs, but the pairs form tight cluster of 10 to over 100 individual flowers that are interspersed with small leaves. These clusters are the "buds" of commercial marijuana. Along the top of the main stem and vigorous branches, "buds" may form so thickly that the last foot or more of stem is completely covered. Usually the leaves that accompany the flowers tend toward simpler structure, until each leaf has one to three blades. {Figure 76. Female in full bloom.}

The visible parts of the female flower are two upraised stigmas, one-quarter to one-half inch long, usually white or cream, sometimes tinged with red, that protrude from a tiny, green, pod-shaped structure called the floral bract. This consists of modified leaves (bracts and bracteoles) which envelop the ovule or potential seed. The mature bract is a tiny structure, about 1/8 inch across and 1/4 inch long. When fertilised, a single seed begins to develop within the bract, which then swells until it is split by the mature seed.

Bracts are covered more densely with large resin glands than is any other part of the plant, and are the most potent part of the harvest. Resin glands may also be seen on the small leaves that are interspersed among the flowers.

The differences between male and female Cannabis become more apparent as the plants mature. The same can be said of the differences between varieties. Often, two varieties may appear to be similar, until they actually flowers and fill out to different forms. These appear in many ways: some varieties maintain opposite phyllotaxy with long internodes throughout flowering; bud sizes vary from about one-half inch to about three inches, with a norm of about one to two inches; buds may be tightly arranged along the stem, yielding a "cola" two feet long and four inches thick; and some varieties only form buds along their main stem and branch tips, with a few "buds" forming along the branches.

{Figure 77. Upper left: Buds form thickly into colas along the top of the main stem and branches (full bloom). Upper right: A cola about two feet long. Lower left: A huge leafy cola. Lower right: Long, slim buds form late in the year when light is weak. (these four colas are from Mexican plants.}

When a female is well-pollinated, growth slows and the plant's energy goes into forming seeds and thus into the continuation of the species. Some plants (but only the more vigorous ones) will renew flowering even when pollinated. Females that are not well-pollinated continue to form flowers rapidly. This extends the normal flowering period, of 10 days to four weeks, up to eight weeks or more.

Individual flowers are pollinated by individual pollen grains. In a matter of minutes from its landing on a stigma, the pollen grain begins to grow a microscopic tube, which penetrates the stigma and reaches the awaiting ovule wrapped within the bracts. The pollen tube is a passageway for the male's genetic contributions to the formation of the embryo (seed).

The union of the male and female complements of genes completes fertilisation and initiates seed formation. The stigmas, having served their purpose, shrivel and die, turning rust or brown colour. On a vigorous female, the seeds reach maturity in about 10 days. When growing conditions are poor, the seed may take five weeks to ripen to full size and colour. Naturally, all the flowers do not form, nor are they pollinated at the same time - and there will be seeds that reach maturity weeks before others do. Although each flower must be individually fertilised to produce a seed, a single male plant can release many millions of pollen grains. A large female plant can produce over 10,000 seeds.

17.3 Sexual Variants in Cannabis

Cannabis has been studied for many years because of its unusual sexuality. Besides the normal dioecious pattern, where each plant bears exclusively male or female flowers, it is not uncommon for some plants to have both male and female flowers. These are called hermaphrodites, or monoecious plants, or intersexes. Hermaphroditic plants form normal flowers of both sexes in a wide variety of

arrangements, in both random and uniform distributions.

Natural Hermaphrodites

Some hermaphrodites seem to be genetically determined (protogenous). That is, they naturally form flowers of both sexes given normal growing conditions. Possibly genes carried on the autosomes (the chromosomes other than the sex chromosomes) modify the normal sexual expression. Monoecious varieties have been developed by hemp breeders in order to ensure uniform harvests.

It is also possible that these particular are polyploid, which means they have more than the usual two sets of chromosomes. This kind of hermaphrodite may have XXY (triploid), or XXYY or XXXY (tetraploid) sex chromosomes. However, no naturally occurring polyploids have ever been verified (by observation of the chromosomes) in any population of Cannabis. Polyploids have been induced in Cannabis by using mutagens, such as the alkaloid colchicine.

Whatever then genetic explanation may be, one or more of these natural hermaphrodites may randomly appear in any garden. They are sometimes faster-maturing, have larger leaves, and are larger in overall size than their unisexual siblings. They usually form flowers of both sexes uniformly in time and distribution, and in some unusual patterns. For example, from Mexican seed, we have seen a plant on which separate flowering cluster consisted of both female and male flowers: and upper section of female flowers had upraised stigmas, and a lower section of male flowers dangled beneath the female flowers. In other plants from Mexican seed, the growing tips throughout the plant have female flowers; male flowers sprout from the leaf axils along the main stem and branches. Plants from "Thai" seed sometimes form male and female flowers on separate branches. Branches with female flowers tend to predominate, but branches having mostly male flowers are located throughout the plant.

Abnormal Flowers, Intersexes, Reversals

Gender is set in the new plant at the time of fertilisation by its inheritance of either the X or the Y chromosome from the male (staminate) plant. With germination of the seed, the environment comes into play. Heritage sets the genetic program, but the environment can influence how the program runs. (Sexual expression in Cannabis is delicately balanced between the two.) The photoperiod, for example, controls the plant's sequence of development. Also, the plant's metabolism and life processes are dependent on growing conditions. When the environment does not allow a balance to be maintained, the normal genetic program may not be followed. This is mirrored by abnormal growth or sexual expression.

{Figure 78. Upper left: Abnormal flowers. Lower left: Male flowers on a female plant. Upper right: Sexes on separate branches. Lower right: Male flower in female bud (reversing).}

Abnormal Flowers

Abnormal sexual expression includes a whole range of possibilities. Individual flowers may form abnormally, and may contain varying degrees of both male and female flower parts. For instance, a male flower may bear a stigma; or an anther may protrude from the bracts of a female flower. Abnormally formed flowers are not often seen on healthy plants, although if one looks hard enough, a few may be found in most crops. When many of the flowers are abnormal, an improper photoperiod (coupled with poor health) is the most likely cause. Abnormal flowers sometimes form on marijuana grown out of season, such as with winter or spring crops grown under natural light.

Intersexes and Reversals Much more common than abnormally formed flowers is for the plant's sex to be confused. One may find an isolated male flower or two; or there may be many clusters of male flowers on an otherwise female plant, or vice versa. These plants are called intersexes (also hermaphrodites or monoecious plants). Intersexes due to environment causes differ from natural hermaphrodite in having random distributions and proportions of male and female flowers. In more extreme cases, a plant may completely reverse sex. For example, a female may flowers normally for several weeks, then put forth new, sparse growth, typical of the male, on which male flowers develop. The complete reversal from male

flowering to female flowering also happens.

All other things being equal, the potency of intersexes and reversed plants is usually less than that of normal plants. If there are reversals or intersexes, both of the sexes will usually be affected. Female plants that reverse to male flowering show the biggest decline. Not only is the grass less potent, but the amount of marijuana harvested from male flowers is negligible compared to the amount of marijuana that can be harvested from a normal female. Plants that change from male to female flowering usually increase their potency, because of the growth of female flower bracts with their higher concentration of resin. Female flowers on male plants seldom form as thickly or vigorously as on a normal female. Between the loss in potency and the loss in yield because of females changing to males, a crop from such plants is usually inferior, in both yield and potency, to one from normal plants.

Environmental Effects

Many environmental factors can cause intersexes and sexual reversals. These include photoperiod, low light intensity, applications of ultraviolet light, low temperatures, mutilation or severe pruning, nutrient imbalances or deficiencies, senescence (old age), and applications of various chemicals (see bibliography on sex determination).

The photoperiod (or time of planting using natural light) is the most important factor to consider for normal flowering. In 1931, J. Schaffner (105) showed that the percentage of hemp plants that had confused sexual characteristics depended on the time of year they were planted. Normal flowering (less than five percent of the plants are intersexes) occurred when the seeds were sown in May, June, or July, the months when the photoperiod is longest and light intensity is strongest. When planted sooner or later in the year, the percentage of intersexuals increased steadily, until about 90 percent of the plants were intersexual when planted during November or early December.

Marijuana plants need more time to develop than hemp plants at latitudes in the United States. Considering potency, size, and normal flowering, the best time to sow for the summer crop is during the month of April. Farmers in the south could start the plants as late as June and still expect fully developed plants.

If artificial light is used, the length of the photoperiod can influence sexual expression. Normal flowering, with about equal numbers of male and female plants, seems to occur when the photoperiod is from 15 to 17 hours of light for a period of three to five months. The photoperiod is then shortened to 12 hours to induce flowering. With longer photoperiods, from 18 to 24 hours a day, the ratio of males to females changes, depending on whether flowering is induced earlier or later in the plant's life. When the plants are grown with long photoperiods for six months or more, usually there are at least 10 percent more male then female plants. When flowering is induced within three months of age, more females develop. Actually, the "extra" males or females are reversed plants, but the reversals occur before the plants flower in their natural genders.

Some plants will flower normally without a cutting of the photoperiod. But more often, females will not form thick buds unless the light cycle is cut to a period of 12 hours duration. Don't make the light cycle any shorter than 12 hours, unless the females have not shown flowers after three weeks of 12-hour days. Then cut the light cycle to 11 hours. Flowers should appear in about one week.

Anytime the light cycle is cut to less than 11 hours, some intersexes or reversed plant usually develop. This fact leads to a procedure for increasing the numbers of female flowers indoors. The crops can be grown for three months under a long photoperiod (18 or more hours of light). The light cycle is then cut to 10 hours. Although the harvest is young (about five months) there will be many more female flower buds than with normal flowering. More plants will develop female flowers initially, and male plants usually reverse to females after a few weeks of flowering.

Of the other environmental factors that can affect sexual expression in Cannabis, none are as predictable as the photoperiod. Factors such as nutrients or pruning affect the plant's overall health and metabolism, and can be dealt with by two general thoughts. First, good growing conditions lead to healthy plants and

normal flowering: female and male plants occur in about equal numbers, with few (if any) intersexes or reversed plants. Poor growing conditions lead to reduced health and vigour, and oftentimes to confused sex in the adult plant. Second, the age of the plants seems to influence reversals. Male plants often show female flowers when the plant is young (vigorous) during flowering. Females seven or more months old (weaker) often develop male flowers after flowering normally for a few weeks.

Anytime the plant's normal growth pattern is disrupted, normal flowering may be affected. For instance, plant propagated from cuttings sometimes reverse sex, as do those grown for more than one season.

17.4 Sexing the Plants

The female plant is more desirable than the male for marijuana cultivation. The female flowering clusters (bus) are usually the most potent parts of the harvest. Also, given room to develop, a female generally will yield twice as much marijuana as her male counterpart. More of her weight consists of top-quality buds.

Because the female yields marijuana in greater quantity and sooner you can devote your attention to nurturing the females. Where space is limited, such as in indoor gardens and small outdoor plots most growers prefer to remove the males as soon as possible, and leave all available space for the females. To harvest sinsemilla (seedless female buds), you must remove the male plants before they mature and release pollen.

Differences in the appearance of male and female Cannabis become more apparent toward maturation. During the seedling stage, gender is virtually impossible to distinguish, although in some varieties the male seedling may appear slightly taller and may develop more quickly.

We know of no way to discover gender with any certainty until each plant actually forms either pollen-bearing male flowers or seed-bearing female flowers. However, certain general characteristics may help. Using guidelines like the following, growers who are familiar with a particular variety can often predict gender fairly accurately by the middle stage of the plant's life.

Early Vegetative Growth

After the initial seedling stage, female plants generally develop more complex branching than the male. The male is usually slightly taller and less branched. (Under artificial light, the differences in height and branching are less apparent throughout growth.)

Some plants develop a marked swelling at the nodes, which is more common and pronounced on female plants.

Middle Vegetative Growth

In the second to fourth months of growth, plants commonly form a few isolated flowers long before the actual flowering stage begins. These premature flowers are most often found between the eighth and twelfth nodes on the main stem. Often they appear near each stipule (leaf spur) on several successive nodes, at a distance two to six nodes below the growing tip. These individual flowers may not develop fully and are often hard to distinguish as male or female flowers. The fuzzy white stigmas of the female flower may not appear, and the male flowers seldom opens but remains a tightly closed knob. However, the male flower differs from the female; it is raised on a tiny stalk, and the knob is symmetrical. The female flower appear stalkless and more leaflike.

The presence of premature female flowers does not assure that the plant is a female, but premature male flowers almost always indicate a male plant. Unfortunately, it is much less common for male plants to develop premature male flowers than for female flowers to appear on either plant. For example, in one garden of 25 mixed-variety plants, by age 14 weeks, 15 plants showed well-formed, premature female flowers with raised stigmas. Eight of these plants matured into females and seven became males. Only two plants showed premature male flowers and both of these developed into males. The eight remaining plants did not develop premature flowers or otherwise distinguishable organs until the actual flowering

stage at the age of 21 weeks. From these eight, there were four females, three males, and one plant bearing both male and female flowers (hermaphrodite). It does seem, however, that plants bearing well-formed female flowers, on several successive node, usually turn out to be females.

Preflowering

In the week or two prior to flowering and throughout flowering, many common marijuana varieties follow two general growth patterns which depend on gender. With these varieties, you can tell gender by the spacing between the leaves (internodes). For the female, the emphasis is on compact growth. Each new leaf grows closer to the last, until the top of the plant is obscured by tightly knit leaves. The male elongates just prior to showing flowers. New growth is spaced well apart and raises the male to a taller stature. This may by the first time the male shows its classic tall, loosely arranged profile.

{Figure 79. Premature flowers are found on the main stem next to the leaf spurs. Upper left: Early female flower without stigmas. Lower left: Undifferentiated (indistinguishable). Centre: Early male flower. Upper and lower right: Well-formed female flowers on successive nodes usually indicate a female.}

17.5 Sinsemilla

Sinsemilla ((The word "sinsemilla" comes from the Spanish, and means "without seeds." It is also spelled "sansimilla.")) is any marijuana consisting of seedless female flower buds. Sinsemilla is not a variety of marijuana; it is the seedless condition that results when the female flowers are not fertilised with pollen.

In the United States, most sinsemilla comes in the form of Thai sticks that are imported from Southeast Asia and Japan. Thai sticks are made up of seedless buds wrapped around a sliver of bamboo or a long wooden matchstick. The buds, which may be on one or more stems, are secured with a hemp fibre wound around the stick. A growing amount of fine sinsemilla now comes from domestic sources, such as Hawaii and California. The grass is usually boxed or bagged with pure buds that are manicured (extraneous leaf removed). Infrequently sinsemilla comes from Mexico and, rarely, from Colombia.

Sinsemilla has a reputation as high-potency marijuana, with a sweet taste and mild smoke. It doesn't have the harsh, gagging qualities of the usual Colombian and Mexican grasses. These qualities, however, have nothing to do with sinsemilla as such. The potency of any grass depends primarily on the variety and development of the plant, and the taste and mildness of the smoke depend on the condition of the plant when harvested and the cure. Heavily seeded grass can be as mild and sweet-smoking as sinsemilla when it is properly handled.

When buying grass, remember that sinsemilla indicates a conscientious effort on the grower's part to bring you the best possible product. Sinsemilla is almost pure smoking material with no wasted weight in seeds. An ounce of sinsemilla has about twice as much smoking material as a typical seeded ounce. Also, any marijuana that is fresh, with intact buds, indicated less deterioration of cannabinoids. {Figure 80. Thai Sticks.}

Sinsemilla is becoming a preferred form of grass with homegrowers, many of whom believe that a seedless female is more potent than a seeded one, reasoning that the plant's energy goes to the production of resin rather than seed. There seem to be no scientific studies on this point. Many experienced growers believe the difference is small, perhaps 10 percent.

From observing the resin glands on the bracts, one sees that they continue to develop in size after pollination. Any difference from the unseeded state is not apparent. Whether pollination does in fact hamper or lessen resin production or potency is questionable. but the effect on the plant as a whole can be dramatic. Usually when the female is well-pollinated, growth noticeably slows, and the plant enters the last phase of life, which is seed set. Seed set is a period of incubation, in which the seeds grow and reach their mature state. New growth forms more slowly and lack the vitality of the bloom before pollination. The plant's reaction to pollination is relative. The more thoroughly pollinated the female is, the more

pronounced the change in rhythm from vigorous to incubation. A plant on which only a few flowers have been fertilised continues to actively form flowers as sinsemilla.

Not all plants react alike to pollination. When the weather is good and the plant vigorous, even a well-seeded plant may bloom a second or third time before the rate of growth starts a final decline.

To put this in perspective, the main advantage to growing sinsemilla is that the plant remains in a flowering state for a longer period of time. Flowers may rapidly form for four to ten weeks. The flower buds develop larger and more thickly along the stems, yielding more top-quality grass (more buds) than in the seeded condition.

Anyone can grow sinsemilla. Simply remove the male plants before they release pollen. Given a normal spring planting, males usually flowers in August and September, but may being to flower as early as mid-July. Under artificial lights, males sometimes flower after only three months, and before the grower has shortened the photoperiod. Even though the females are not flowering, remove the males from the room before any flowers open. Indoor, the pollen will collect as dust and can fertilise the females weeks later.

Male flowers mature quickly, in about one to two weeks after the immature buds are first visible. Check each plant about twice a week to make sure you harvest all the males before any shed pollen. If you can't visit your garden consistently, then thin the garden, using the preceding section on "Sexing" as a guide. Even though you may not get all the males, the females will be more lightly seeded. Actually, even in carefully watched gardens, the females may have a few seeds. Pollination may come from on occasional male flower on a basically female plant, or a female may reverse and form male flowers. And pollen may come from a neighbour's garden, a problem that is becoming more common. But in practical terms, an occasional seed makes no difference. The female can form thousands of flowers, and when only a few are pollinated, there is little impact on the plant's growth.

Chapter 18
PROPAGATION AND BREEDING

18.2 Producing Seeds

Marijuana is naturally prolific. It has been estimated that a single male plant can produce over 500 million pollen grains 41. A large female plant can bear tens of thousands of seeds. In nature, pollen is carried from the male flowers to the stigmas of the female flowers by air currents or the wind. Indoors or out, if the plants are simply left on their own, most gardens produce many more seeds than are needed for the next crop.

Seeds usually become viable within two weeks after pollination, although they may not have developed good colour by this time. The colour can take several more weeks to develop, particularly indoors or late in the year, when the light is not as strong. Once seeds are plump, well-formed, and of a mature size, most of them will be viable. When seeds have also developed good colour, their viability should be over 90 percent.

Pollination may also be carried out artificially. Pollen can be collected and the transferred to the female flowers with a cotton swab or artist's brush, or shaken directly over the flowers. Store pollen in a clean, open container and keep in a dry area at moderate temperature. Remove any flowers or vegetative matter from the pollen, because they encourage fungal attack.

Once advantage of artificial pollination is that only the flowers on certain plants need be pollinated. This allows you to harvest most of your grass as sinsemilla, while developing seed on part of the plant. If you have only a few plants, pollinate a single branch, or perhaps only a few lower buds, in order to leaves the most potent buds seedless.

A good way to insure a thorough pollination, and to avoid contaminating other females, is to loosely tie a transparent bag containing pollen directly over individual buds, branches, or whole plants. Shake the bag to distribute the pollen and carefully remove it from several hours to a few days later.

To avoid contaminating a sinsemilla crop, you must remove any males from the garden before their flowers open. Males in pots can simply be moved to another area or room if you want to keep them growing. Male plants can complete development even in low light; so they do not need artificial light. Otherwise, the best procedure is to harvest the males intact by cutting them at their base after some flowers have formed distinct (but unopened) buds. Hang the whole plants upside down in a sheltered area where there is moderate light and where temperatures and humidity are not extreme. Place clean plates or sheet plastic beneath the plants to catch falling pollen. Generally there is enough stored water in the plant for the unopened flowers to mature and drop pollen. Well-formed flowers may open the next day. Usually all the flowers that are going to open will do so within two weeks.

Pollen gradually loses viability with time, but pollen that is about three weeks old generally has sufficient viability for good seed production. However, the age of the pollen may influence the sex ratio of the next generation.

For instance, in a 1961 study with hemp plants 97, the percentage of females in the next generation was 20 percent higher than in the control plants (natural pollination) when pollen 14 to 17 days old was used. A small increase in female-to-male ratios also occurred when pollen was fresh (six hours or less). The age of the stigmas appeared not to affect the sex ratio.

18.3 Producing Female Seeds

If it were possible to know which seeds are female and which are male, marijuana growing would be even simpler than it is. There is not practical way to discern the gender of a seed - but there is a simpler procedure for producing seeds that will all grow into female plants.

To produce female seeds, the plants are fertilised with pollen with male flowers that appear on a basically female plant. Such flowers appear on intersexes, reversed females, and hermaphrodites (see section 17). Female plants have an XX complement of sex chromosomes; therefore, the pollen from the male flowers that form on female plants can only carry an X chromosome. All seeds produced from flowers fertilised with this "female" pollen will thus have an XX pair of sex chromosomes, which is the female genotype.

Although the male Cannabis plant can produce female flowers, it cannot produce seed; so there is no chance of mistakenly producing seed on a male plant. It is possible to use pollen from an intersexual plant that is basically male (XY); the resulting crop of seeds will have the normal 1:1 ratio of males to females. For this reason, choose a plant that is distinctly female as a pollen source. A female plant with a few random male-flower clusters, or a female plant that has reversed sex are both good pollen sources. The seed bearer can be any female, female intersex, or reversed-female plant.

In most crops, careful inspection of all the females usually reveals a few male flowers. And often, when females are left flowering for an extended period of time, some male flowers will develop. If no male flowers form, you can help to induce male flowers on female plants by severe pruning. One such procedure is to take the bulk of the harvest, but to leave behind some green leaves to maintain growth (as described in the section on "Double Harvests" in section 20). Most of the plants will continue to form female flowers, but male flowers are also likely to form. At times, the plants may not grow particularly well, and may in fact form distorted and twisted leaves, but they will produce viable seeds as long as some stigmas were white when pollinated. (Remember, it only takes a few fertile buds to produce hundreds of seeds.) Pollinate the female flowers by hand as soon as pollen becomes available.

{Figure 82. A solitary male flower on a female plant provides "female" pollen. (Also see Figure 84 for a female reversing sex.)}
{Figure 83. Growth may not be vigorous, but seeds will form if stigmas are white when pollinated.}

Under artificial lights, turn the light cycle down to eight hours after cutting the plants back. The short cycle helps to induce male flowers on female plants.

Male-free seed can also be produced by pollen from a natural hermaphrodites. The progeny, however, may inherit the hermaphroditic trait, resulting in a crop with some hermaphrodites as well as females. This could be a problem if you want to grow sinsemilla the next crop.

18.4 Breeding

Breeding Cannabis is done simply by selecting certain plants to be the pollinators and the seeds bearers. Characteristics such as fast growth, early maturation, and high potency might be the reasons for choosing one plant over another. Selection can be by means of the male plants, the females, or both. A simple procedure would be to harvest all male plants, sample each for potency, and use the most potent plant for the pollen source. At harvest, compare the seeded females for potency, and use seeds from the most potent plant for the pollen source. At harvest, compare the seeded females for potency, and use seeds from the most potent plant for the following generation.

There are two basic approaches to breeding. One is inbreeding, and the other is outbreeding. Inbreeding involves starting with a single variety and crossing individuals to produce seeds. In this way, certain desirable characteristics that the parents have in common will probably be perpetuated by the offspring.

Certain variants with unusual characteristics, such as three leaves to a node instead of the usual two leaves, can be inbred continuously until all progeny carry the trait. One problem with inbreeding is that other desirable characteristics may be lost as the new population becomes more homogeneous. Inbreeding plants indoors seems to lead in a loss in potency by the fourth generation. (Preceding generations were considered comparable to the original imported grass.)

Outbreeding is crossing two different varieties. Offspring from parents of two different varieties are called hybrids. Cannabis hybrids exhibit a common phenomenon on plants called "hybrid vigour." For reasons not wholly understood, hybrids are often healthier, larger, and more vigorous than either of their parents. {Figure 84. Upper left: An old female reversing to male flowering. Lower left: Three leaves to a node (trifoliate). Upper right: A plant with three leaves to a node alternating with one leaf on next node. Lower right: Three-leafed plants sometimes split into two growing shoots.}

A reference to cannabinoid content of hybrids from crosses between chemotypes was made in a 1972 study by the Canadian Department of Agriculture: "The ratio of THC to CBD in hybrids was approximately intermediate between the parents ... there was also occasionally a small but significant deviation toward one of the parents - not necessarily the one with the higher or lower ratio of THC to CBD." 51 This means that a cross between a midwestern weedy hemp (type III) and a fine Mexican marijuana (type I) would yield offspring with intermediate amounts of THC and CBD, and which hence would be considered type II plants.

Homegrowers have mentioned that inbreeding plants often led to a decrease in potency after several generation. Outbreeding maintained potency, and sometimes (some growers claimed) led to increases in potency.

One area in which breeding can be useful for homegrowers is the breeding of early-maturing plants for northern farmer. Farmers in the north should always plant several varieties of marijuana. Mexican varieties generally are the fastest to mature. Individual plants that mature early and are also satisfactorily potent are used for the seed source in next year's crop. This crop should also mature early. Some growers cross plants from homegrown seed with plants from imported seed each year. This assures a maintenance of high-potency stock.

Potency Changes Over Generations

It is well-established that plants of the P1 generation (parentals, or the first homegrown plants from imported seed) maintain their chemical characteristics. (For example, type I plants yield type I progeny

whose cannabinoids are about equal both quantitatively and qualitatively to those in their native grown parents.) This fact is shown by Table 25.

In the study 66 from which Table 25 has been adapted, individual plants within varieties differed by more than four times in CBD content and by more than three times in THC content. The researchers also noted that illicit marijuana samples contained proportionately less leaf material and proportionately more stem and seed material than samples grown in Mississippi. (Mississippi samples may be more dilute.) New Hampshire and Panama samples were nearly equal in terms of the sum of THC plus CBN.

One of the questions that persists in marijuana lore is what effect if any a change in latitude has on the plant chemotype over a period of generations. Non-drug types of Cannabis usually originate above 30 degrees latitude in temperate areas. Drug types of Cannabis usually originate in tropical or semitropical areas below the 30-degree parallel. Whether this is due entirely to cultural practices is questionable. More likely, the environment (natural selection) is the prime force, and cultural practices reinforce rather than determine chemotype.

Cannabis is notorious for its adaptability. Historically, there are many statements that the drug type of Cannabis will revert to the "fibre" type when planted in temperate areas, whereas the fibre type will revert to the drug type after several generations in a tropical area. That a change in chemotype is actually caused by transfer between tropical and temperate areas has not been verified scientifically. (Such studies are ongoing in Europe.) If such changes occur, it is also not known whether the change is quantitave (the plant produces less total cannabinoids) or whether it is qualitative (succeeding generations, for example, change from being high in THC and low in CBD to being high in CBD and low in THC).

We believe that qualitative changes can occur within a few generations, but can only guess what environmental factor(s) might be responsible for such a change. Probably the change has more to do with adaption of general growth and developmental characteristics than with particular advantages that production of either CBD or THC may bestow upon the plants.

The reason we suspect a change in chemotype is that these changes occur rapidly in evolutionary terms, in a matter of several generations. This rapidity implies that some very strong selective pressure are acting on the plant populations. Also, changes in the chemotype seem to occur globally, which implies that the selective pressures responsible are globally uniform rather than local phenomena. Such globally uniform pressures might be light intensity, daylength, ambient temperatures, and the length of the growing season. For example, in populations adapting to temperate areas, those plants that are able to grow well under relatively lower light intensity and cooler temperatures, and which are able to complete development in a relatively short growing season, would be favoured over siblings with more tropical characteristics.

Adaption acts on populations by means of whole organisms which are reacting to a total environment. Shifts in the chemotype of the population are probably linked genetically to the strong selective pressures exerted on the populations by the need to adapt general growth and maturation to either northern (temperate) or southern (tropical) conditions. {From the northern hemisphere.}

18.5 Cuttings

Marijuana growing often transcends the usual relationship between plant and growers. You may find yourself particularly attached to one of your plants. Cuttings offer you a way to continue the relationship long beyond the normal lifespan of one plant.

To take a cutting, use scissors or a knife to clip an active shoot about four to sic inches below the tip. Cannabis does not root easily compared to other soft-stemmed plants. Cuttings can be rooted directly in vermiculite, Jiffy-MIX, a light soil, or in a glass of water. The cutting is ready to plant when roots are about an inch long, in about three to four weeks. A transplant compound such as Rootone can be used to encourage root growth and precent fungi from forming.

Keep the mixture consistently moist but not too saturated. Roots need oxygen as well as water in order to grow. Change the water daily if the cutting are in a glass of water. Cuttings root best in moderate light, not in intense light (HID's) or direct sunlight. The best light is fluorescent set on constant light (24 hour photoperiod).

{Picture. Comparing rooting mediums. Left to right: One, roots both in and removed from rockwool cube; two, perlite; three and four, perlite vermiculture mixture; five, vermiculite; not shown: cuttings died in peat-pellets. Best rooting was in perlite-vermiculite mixture. Pure vermiculite also worked well.}

Cuttings taken from the same plant are genetically identical and are clones. Clones eliminate genetic differences between individuals, and hence are particularly useful in scientific experiments. By using clones, one can attribute variations between individuals specifically to outside factors. This would be particularly useful when testing, for example, the affect of fertilisers on potency. In the 1980's, scientists finally began to use this useful tool in Cannabis experiments.

18.6 Grafting

One of the most persistent myths in marijuana lore concerns grafting Cannabis to its closest relative. Humulus, the hops plant of beer-making fame. The myth is that a hops scion (shoot or top portion of the stem) grafted to a marijuana stock (lower stem and root) will contain the active ingredients of marijuana. The beauty of such a graft is that it would be difficult to identify as marijuana and, possible, the plant would not be covered under marijuana statutes. Unfortunately, the myth is false. It is possible to successfully graft Cannabis with Humulus, but the hops portion will not contain any cannabinoids.

In 1975, the research team of Crombie and Crombie grafted hops scions on Cannabis stocks from both hemp and marijuana (Thailand) plants 205. Cannabis scions were also grafted to hops stocks. In both cases, the Cannabis portion of the graft continued to produce its characteristic amounts of cannabinoids when compared to ungrafted controls, but the hops portions of the grafts contained no cannabinoids. This experiment was well-designed and carried out. Sophisticated methods were used for detecting THC, THCV, CBD, CBC, CBN, and CBG. Yet none of these were detected in the hops portions.

The grafting myth grew out of work by H.E. Warmke, which was carried out for the government during the early 1940's in an attempt to develop hemp strains that would not contain the "undesirable" drug 58. The testing procedure for the active ingredients was crude. Small animals, such as the water flea Daphnia, were immersed in water with various concentration of acetone extracts from hemp. The strength of the drug was estimated by the number of animals killed in a given period of time. As stated by Warmke, "The Daphnia assay is not specific for the marijuana drug ... once measures any and all toxic substances in hemp (or hop) leaves that are extracted with acetone, whether or not these have specific marijuana activity." Clearly it was other compounds, not cannabinoids, that were detected in these grafting experiments.

Unfortunately, this myth has caused some growers to waste a lot of time and effort in raising a worthless stash of hops leaves. It has also leg growers to some false conclusions about the plant. For instance, if the hops scion contains cannabinoids, the reasonable assumption is that the cannabinoids are being produced in the Cannabis part and translocated to the hops scion, or that the Cannabis root or stem is responsible for producing the cannabinoids precursors.

From this assumption, growers also get the idea that the resin is flowing in the plant. The myth has bolstered the ideas that cutting, splitting, or bending the stem will send the resin up the plant or prevent the resin from going down the plant. As explained in our discussion of resin glands in section 2, these ideas are erroneous. Only a small percentage of the cannabinoids are present in the internal tissues (laticiferous cells) of the plant. Almost all the cannabinoids are contained and manufactured in the resin glands, which cover the outer surfaces of the above-ground plant parts. Cannabinoids remain in the resin glands and are not translocated to other plant parts.

We have heard several claims that leaves from hops grafted on marijuana were psychoactive. Only one such case claimed to be first hand, and we never did see or smoke the material. We doubt these claims. Hops plants do have resin glands similar to those on marijuana, and many of the substances that make up the resin are common to both plants. But of several species and many varieties of hops tested with modern techniques for detecting cannabinoids, no cannabinoids have ever been detected 212.

The commercially valuable component of hops is lupulin, a mildly psychoactive substance used to make beer. To our knowledge, no other known psychoactive substances has been isolated from hops. But since these grafting claims persist, perhaps pot-heads should take a closer look at the hops plant.

Most growers who have tried grafting Cannabis and Humulus are unsuccessful. Compared to many plants, Cannabis does not take grafts easily. Most of the standard grafting techniques you've probably seen for grafting Cannabis simply don't work. For example, at the University of Mississippi, researchers failed to get one successful graft from the sixty that were attempted between Cannabis and Humulus. A method that works about 40 percent of the time is as follows. (Adapted from 205)

Start the hops plants one to two weeks before the marijuana plants. Plant the seeds within six inches of each other or start them in separate six-inch pots. The plants are ready to graft when the seedling are strong (about five and four weeks respectively) but their stem has not lost their soft texture. Make a diagonal incision about halfway through each stem at approximate the same levels (hops is a vine). Insert the cut portions into each other. Seal the graft with cellulose tape, wound string, or other standard grafting materials. In about two weeks, the graft will have taken. Then cut away the unwanted Cannabis top and the hops bottom to complete the graft. Good luck, but don't expect to get high from the hops leaves. {Smoking any plant's leaves will give a short, slight buzz.}

18.7 Polyploids

H.R. Warmke also experimented with breeding programs during the war years. Polyploid Cannabis plants were produced by treatment with the alkaloid colchicine. Colchicine interferes with normal mitosis, the process in which cells are replicated. During replication, the normal doubling of chromosomes occurs, but colchicine prevents normal separation of the chromosomes into two cells. The cell then is left twice (or more then) the normal chromosome count.

Warmke's experiments concluded that polyploids contained higher concentrations of the "active ingredient." However, the procedure for measuring that ingredient was much the same is described for grafting, with probably similar shortcomings.

Polyploid Cannabis has been found to be larger, with larger leaves and flowers. Recent experience has shown that polyploids are not necessarily higher in potency. Usually they are about equal to diploid siblings.

Colchicine is a highly poisonous substance. The simplest and safest way to induce polyploids is to soak seeds in a solution of colchicine derived from bulbs of winter or autumn crocus (Colchicum). Mash the bulbs and add an equal part of water. Strain through filter paper (or paper towels). Soak seeds in the solution and plant when they start to germinate. Cultivate as usual.

Only some of the seeds will become polyploid. Polyploid sprouts generally have thicker stems, and the leaves are often unusually shaped, with uneven-sized blades. Leaves also may contain more than the usual number of blades. As the plant grows, leaves should return to normal form, but continue to be larger and with more blades.

If no polyploids sprout, use less water in preparing the solution.

Colchicine is also a prescribed drug for treatment of gout and is taken in pill form. These usually contain .6 mg per tablet. Use 10 tablets per ounce of water, and soak the seeds as described above.

Colchicine is also sold by mail-order firms which advertise in magazines such as Head or High Times.

Because colchicine is a poison, it should be handled carefully. It is not known if plants from seeds treated with colchicine will contain a harmful amount of colchicine when plants are grown. Harm is unlikely, because the uptake by the seed is so small, and because the colchicine would be further diluted during growth, as well as diminished by smoking. But we cannot guarantee that you can safely smoke colchicine-treated plants.

Chapter 19
EFFECTS OF THE ENVIRONMENT ON POTENCY

This chapter deals only with the influence of the environment on the potency of your crop. Differences or changes in potency can also result from inherent differences between plants, such as in their variety or growth stage, from chemical degradation of the harvested marijuana, and from genetic processes that take place over several generations of plantings ((For discussion of these other causes of differences in potency, see the following sections: "Cannabis Chemotypes" in section 2; "Inherent Variations" in section 3' "Breeding" in section 18; "Potency and Decomposition" in section 20; and "Storage" in section 21.))

We have emphasised the heredity is the most important factor that determines potency. Potent marijuana grows from seeds of potent marijuana. A healthy, mature plant bears an abundance of flowers, guaranteeing you a potent harvest.

Some researchers have investigated the impact of the environment on relative potency, since this question is of interest to officials concerned with marijuana control as well as to marijuana growers. Their primary goal has been to discover the gross effects of different environments rather than to single out the effects of any particular factor. A consensus is that the impact of environment on potency is small relative to that of the plant's heredity. Nevertheless, where scientists have commented on this question, the common denominator for higher potency has been stress.

19.2 Stress

Stress in anything that detracts from the plant's health or vigour. Environmental factors such as competition from other plants, low water availability, and poor soil conditions are examples of stress factors.

In many marijuana-growing cultures, farmers have practices that are stress-related; splitting the base, severe pruning, bending or contorting the stem, and water deprivation are common examples. Of course, the fact that marijuana-growing cultures have such practices does not mean that these practices actually increase potency, or that this is, or ever was, their intent. This original meaning may well have been forgotten centuries ago. For instance, cultivation of sinsemilla has been practiced for centuries, not for potency, but because the seedless product is easier to process or smoke.

There does seem to be some underlying relationship between stress and higher potency. Stress factors may slow growth in general, but at the same time, may not slow the synthesis of cannabinoids. Potency may be affected in much the same way by growth factors that are not considered stressful. As described previously, marijuana plants grow more compactly and have smaller leaves under conditions of relatively warm temperatures, or strong sunlight, or a dry atmosphere; they grow taller and have larger leaves when grown under cool temperatures, moderate light, or a humid atmosphere. Higher relative potency seems to correlate with conditions which favour compact development of the plant and its parts.

The rate of cannabinoids synthesis relative to photosynthesis may be affected in ways not apparent. Sunlight, for instance, is a growth factor. In almost all cases, the more sunlight the plants receive, the faster and larger they will grow. Yet plants grown with intense sunlight seem to maximise potency. Intense sunlight can raise plants' internal temperatures to levels that interfere with the photosynthesis cycle. Absorption of light energy and conversion to biochemical energy continues unimpeded, but the synthesis of sugars is impeded. (Under a midday sun, this phenomenon has been observed in other field

crops. (206)) In marijuana, cannabinoids synthesis may continue unaffected at these higher temperatures. This might account, in part, for the slightly higher potency of plants grown in tropical zones.

The subject of potency is mired in confusion and mystery, largely because of fertiliser and soil ads, marijuana-growing books, and individuals who promise ways of increasing potency or growing super grass. There are no magic formulas or secrets to divulge that will make or break the potency of your crop. We have tried to play down this type of thinking throughout this book. Choice of seed, and a harvest of well-developed buds, far outweigh any other factors in determining potency.

We know of no one who has demonstrated that manipulation of any particular environmental factor leads to higher potency. This lack of demonstration probably exists for two reasons: (1) environmental effects on potency are relatively small compared to the effects of inheritable traits, and hence are not easy to discern; and (2) "increased potency" is difficult to prove ((Most scientific experiments are observations, and test effects or compare results rather than try to prove something.)) The variations in potency within any variety, and within each plant, require stringent methods of sampling for comparative tests. And since potency also changes with time, meaningful comparisons can be difficult to make. Scientific papers reflect this difficulty.

An experiment on potency must account for inherent variations in potency before environmental effects can be analysed. Samples would need to be equivalent in terms of variety, growth stage and development, sex, plant part, and the position of the part on the plant. A simple way to do this would be to harvest females when each reached full bloom and then compare the uppermost buds from each plant.

Most of the research on potency done to date either has not reported sampling techniques or did not account for certain inherent variations. In the extreme case, all vegetative matter from one plant was mixed together, and the THC concentration in a sample of this matter was compared with that in a similar sample of mixed marijuana from another plant. Such practices can give misleading results. Consider the fact that an unhealthy plant will have dropped many of its lower, less-potent leaves. A healthy plant has more leaf overall and retains more of its lower leaves. There is a good chance that the unhealthy plant will test higher in average THC content, because proportionately shoots, which are relatively more potent. Such a sampling error could create the impression that stress is positively correlated with potency.

Marijuana scientists have recognised the need for testing equivalent samples and for setting standards for testing. In 1974, the English scientist John Fairburn (68) published a number of well-controlled experiments concerning potency and light. This is a hopeful sign that more meaningful experiments will be forthcoming.

We have said that the common denominator for increasing potency is stress. Let's put that in perspective.

You cannot go wrong if you grow the largest and healthiest plants possible. Our experience has been that the most potent plants are more often the healthiest and most vigorous in the garden.

Factors that limit growth rate are probably related to potency, and if growth rate is relatively slower, cannabinoids concentrations may be higher. Plants whose average yield is six ounces may be slightly more potent than plants whose average yield is eight ounces. Factors related to potency affect growth rate rather than ruin the plant's health. When a plant is so traumatised that it is barely surviving, potency as well as growth rate declines.

Obviously, if the growth rate is slower, the harvest will be smaller. Any difference in potency due to stress is quite small, but the difference in yield can make the difference between harvesting an ounce and harvesting several pounds (ie., don't get carried away with the practice of stressing the plants). If you wish to stress the plant, wait until it is firmly established and growing well.

Outdoors, don't stress the plant until at least the middle of its life. You want the plant to be large enough to bear a good harvest of buds. Water deprivation is a good method of limiting growth outdoors. However, wilted plants must be watered, or they will die.

Competition from other weeds has been correlated with higher potency in two recent studies (71,74). You might prefer not to weed your patch after the seedling stage. (Initially, weeding is necessary because indigenous weeds generally outgrow marijuana seedlings.)

Another safe way of applying stress is to remove all large leaves from the plant once it has begun to flower.

Indoors, the plants are already in a delicate state. We advise indoor growers to grow the largest and healthiest plants possible for best results.

19.3 Nutrients

Most growers show a keen interest in fertilising, since it is one factor over which they have some control. Most growers also feel that nutrients, which play such an important part in plant growth, probably have a relationship to the potency, and this is a reasonable assumption. In marijuana lore, potency is sometimes attributed to particular soil types (for instance, red dirt, which is iron-rich) or to presence or lack or certain nutrients (for examples, nitrogen or potassium deficiency).

The relationship of potency to soil conditions, in particular the nutrient content, has been looked at recently by several research groups. In two such studies, (71,74) the cannabinoid content of naturalised weedy hemp stands in the Midwest was examined. Variations in potency were then correlated to soil properties, such as N, P, and K content. The two papers came to similar conclusions. First, stands growing in areas where they were under stress tended to produce less biomass (yield) but were more potent overall. Second, when nutrients or other growth factors, such as height and weight of plants or root size, were correlated with potency, potency was almost always correlated positively with positive growth factors. That is, higher potency occurred when the plants were growing with adequate or high amounts of nutrients present, not when nutrients were inadequate.

What appears to be a contradiction (stress leads to higher potency, or good growing condition lead to higher potency) may be explainable in terms of what these experiments actually measured.

A basic assumption in these studies was that all the plants were relatively homogeneous genetically, since they may have originated from a single stock of hemp grown during World War II. Assuming this is true, then variations between stands would be due to differences in local environmental factors. However, since environmental condition differed locally for separate stands, one cannot tell whether variations in potency between stands are due to present environmental factors (phenotypic responses) or reflect thirty years of adaption by each stand to its local environment (genotypic shifts).

It may be that positive growth factors are associated with higher potency in phenotypes (plants now growing), whereas stress leads to higher potency in succeeding generations, because of selective pressure. It is interesting that both papers reported strong positive correlations between higher potency and competition from other weeds, since competition between plants does exert strong selective pressures.

The following list of possible effects of nutrients on potency has been adapted from these four studies. (63,71,74,231)

Nitrogen

Nitrogen was positively correlated with higher potency. Once controversy in marijuana lore is whether a nitrogen deficiency during flowering increases potency. We have grown plants with N deficiencies, and they seemed no more potent than those grown with high amounts of nitrogen available. However, the N-deficient plants did produce a much smaller harvest.

Phosphorus

P has been correlated positively with higher potency in all studies that have examined this factor. Phosphorus is necessary for good flower development and seed production. Give the plants a steady

supply of phosphorus throughout growth and in particular during flowering.

Potassium

K has been correlated both positively and negatively with potency. More often, it has been found to be negatively correlated. As discussed previously, plants that show some potassium deficiencies may grow well; so you may choose not to treat minor symptoms of K deficiency often grows vigorously with little harm other than the spotting and the loss of some lower leaves. It should not be necessary to fertilise with potassium during flowering unless deficiency symptoms are severe and the plant has ceased growing.

Calcium

Abundant Ca levels have been consistently correlated with higher potency.

Magnesium

Mg has been negatively correlated with potency. However, this may have been dur to the interaction of Ca and Mg, and may reflect Ca's strong positive correlation to potency, rather than the negative effects of Mg per se. Plants that show Mg deficiencies must be fertilised, or they will quickly lose most of their leaves and barely remain alive.

Chapter 20
HARVESTING

Figure 30 is a hypothetical plot of the increase in potency of a male plant and a female during the course of their growth. (Potency is measured by the percentage by weight of THC in a dried sample of the uppermost leaves or growing shoots until flowers appear.) It shoes that generally potency increases as the plant develops. Cues such as phyllotaxy changes and rate of growth are helpful indicator to changes in development and the chronological age of the plant has little significance.

The development of the cannabinoids, resin glands, and, in practical terms, the potency in the living plant is not clearly understood. We believe that,, for the most part, potency does not increase steadily throughout the entire plant. Rather, each plant part reaches a point of maximum potency as it individually develops. A leaf that is formed when the plant is four weeks old does not increase in potency during the rest of the season. To say that potency is increasing means that the leaves that are now forming are more potent than those previously formed.

We also believe that cannabinoid formation is very fast as each plant part forms. Once matured (for example, when a leaf is fully expanded), cannabinoids are decomposing. This is one reason why the potency can decrease as well as increase during growth, especially late in the season, after the flowers have formed. The practical aspects of these points are detailed in the following sections.

20.2 Harvesting During Growth: Leaves and Growing Shoots

Leaves

We have emphasised that you should harvest grass during the course of the season. One reason is to assure yourself a return for your efforts. It is a sad commentary on our times that the greatest danger in growing marijuana outdoors is that the plants may be ripped off. On a more positive note, vegetative shoots and leaves can be surprisingly potent and should be sampled.

The potency of each new set of leaves is higher than the last pair until a plateau is reached, usually during the middle of vegetative growth. Thereafter potency of new leaves stays about the same as in those preceding. Often there is a noticeable decline in potency just prior to flowering. Leaves that form during flowering are usually more potent than those formed during the vegetative plateau. Leaves that

form after the bloom are less potent.

Of course, not all varieties or individual plants will follow this rhythm. Faster-developing plants may reach the plateau sooner, and slower plants later. Potency of plants that have a longer life cycle may stay at the vegetative plateau for several months. Some plants do not seem to experience any drop in potency before flowering. Potency of these plants continues to increase gradually after the initial quick increase during early vegetative growth.

Whenever you harvest green leaves during growth, you should always take the uppermost leaves, since these are the most potent. Also, the smaller leaves that form on the branches are more potent than the large leaves on the main stem. These large stem leaves (fan, shade, or sun leaves) are often the first leaves that growers pick. But these are the least potent of all leaves, and the may not get you high at all. As long as these leaves are healthy and green, let them stay on the plant for the plant's growth. Many growers simply use these leaves for mulch or compost as they die.

Don't think that you should harvest each leaf as soon as it appears; this procedure would seriously affect normal growth and result in a small harvest of buds. The potency of individual leaves does not increase during the course of the season, but the decrease in potency is not great. Some of the loss in potency may even be made up for by the loss in tissue weight that a leaf experiences as it dies. Many growers prefer to harvest leaves during growth only after they lose colour, preferring the taste of the smoke to that of green leaves.

Leaves should always be harvested if they die; with indoor gardens, remove any leaves that show signs of insects or other pests.

Do keep yourself supplied with grass (that is the reason you are growing the plant); just don't overdo it. The main harvest is made up of buds, and you want a large, healthy plant that can support vigorous flowering. The larger and healthier a plant is, the more leaf you can harvest without seriously affecting the plant.

Growing Shoots

You may prefer not to clip the growing shoot of the main stem. This forms the largest and most potent cola by harvest time. Plants grown close together usually are not clipped, so that the plants may grow as tall as possible. Where there is much space between plants, the main shoot is clipped to encourage the plant to develop its branches, which fill the available space.

The potency of growing shoots follows the rhythm described for new leaves. However, growing shoots can be the most potent parts of the harvest when picked at the right time. Shoots sometimes reach a very high peak of potency during the middle of vegetative growth. Outdoor gardens should be samples from mid-June through July, since this is the period in which shoots usually reach their peak.

Potency also fluctuates according to local weather conditions. Try to harvest after a period of clear, sunny weather. Potency may declining for several days after a period of cloudy weather or heavy rainfall. After a heavy rain, harvest the shoots a week or two later, since the shoots often peak in potency during a burst of fast growth.

Growing shoots can be harvested from each plant at least twice during growth. The first clipping may not give you much worthwhile grass, but it is done when the plants are young (roughly six weeks old) to force the plant to develop several growing shoots which are harvest about six to eight weeks later. The main shoot is clipped, leaving about four or five nodes below the cut. Two shoots should start to grow from each node, the strongest at the top of the plant and the weakest at the bottom. (This difference is more pronounced under artificial light, since the light is strongest on the top of the plants.) Each plant should produce at least six strong growing shoots after this first clipping. The yield from growing shoots can be considerable (especially during the summer marijuana drought) and will probably keep you supplied until the main harvest.

A third harvest of shoot can be made later if the plants have a long growing season or are indoors. You don't want to clip shoots from the plants just prior to or during flowering, since doing so cuts down on the harvest of buds. Each plant should have at least twelve growing shoots after being clipped twice previously. You might harvest only a few shoots from each plant if the time for flowering is near.

20.3 Male Plants

Male plants usually do not have the dramatic increase in potency during flowering that the females do. Male flowers take about two weeks to mature, from the time they are first visible as tiny knob-like buds. New flowers continue to appear for several weeks.

When male flowers open and are about to release pollen, they reach their maximum potency. Since all flowers do not mature at the same time, for maximum potency the plants should be harvested after the first few flowers have opened.

Male flowers actually make up little of the total weight of the harvest, and few new leaves form once flowering begins. There is no significant loss in either potency or yield if the male is harvested before its flowers open. Once male flowers appear, there is little change in their potency. Also, once the flowers do open and release pollen, they shortly fall from the plant and are lost to the harvest.

Males should therefore be harvested before any flowers open unless you want the females to produce seeds. In a small garden, male flower clusters can be individually harvested as they mature. Most growers treat male flowers more as a novelty. Potency of male flowers is quite variable, and seldom are they as good as the female flowers. To remove male plants, cut them near the base of the stem. Don't rip them up by the roots if they are near females that will be left to grow.

Male plants normally begin to lose their vigour after the initial bloom. When the weather is mild, or the plants are indoors, they can be encouraged to bloom a second and sometimes a third time before they finally die.

20.4 Harvesting Female Buds

The decision of when to harvest females can be simplified by understanding that you want to pick the buds after they have developed fully, but before degradation processes begin to lower potency. There are two criteria you can use to tell when the plants have reached full bloom. The first is recognising the rhythm, with which the plants are blooming. A second is the condition of the flowers as judged by the health of the stigmas and the colour of the resin.

Sinsemilla

Since sinsemilla flowers are not pollinated, the flowering period may last for many weeks. The most common rhythm for sinsemilla is that plants go through a stage of rapid bud formation, and the plants do indeed bloom. This bloom often lasts four to five weeks. The bloom ends when the rate at which new flowers form noticeably declines. At his time you should be able to sense that the bloom is completed. Buds are at their peak potency about one week after flower formation slows. This is the time to harvest. True, the plant may continue to grow slowly, but the main harvest is ready and should be taken.

With sinsemilla, some marijuana varieties have an extended bloom that may last more than two months. With this rhythm, the rate at which the buds form is drawn out, and progresses at a slower but steadier pace. The point at which the bloom is essentially over may not be as obvious as in the first case. Here, use the condition of the buds to make your decision. Stigmas wither first at the base of the buds (older flowers). Those stigmas at the top of the buds (younger) will still be white and healthy, although their tips are often brown. Harvest the plants when about half the stigmas in the buds have withered. The coating of resin glands should still be clear or white, with only a few golden or browned gland heads.

A third type of flowering rhythm is sometimes seen on plants from Thai seed. Flower buds bloom and ripen at different times. These plants also have an extended flowering stage that can last for over two

months. You may choose to harvest individual buds, colas, or branches as they ripen.

Seeds

If your primary interest is seeds, the plant should be harvested after the seeds have developed their mature colour. Mature seeds can be seen splitting their sheaths or bracts. When enough seeds have ripened, the plants should be harvested. If the plants are left in the ground and die, many of the seeds will fall from the plant.

For most growers, potency will be of primary interest, seeds only a secondary. With seeded marijuana, flowering is initially rapid until the plant is well-pollinated. If pollination occurs early in flowering, the plants often bloom for another week or two. Generally, you want the plants to flower for at least four weeks before picking, and usually longer, about six to seven weeks.

With seeded marijuana, the bloom is of shorter duration than with sinsemilla. Once growth slows, wait another two to three weeks before harvesting. All the seeds may not be matured, particularly at the top of the bud. But potency of the buds should be about maximum at this time.

20.5 Weather

Because of such variables as variety and growing conditions, there can be so much variation in the ripening process that no one criterion for judging when maximum potency is reached will be reliable for all cases.

Warm, sunny weather encourages rapid flowering and a long period of receptivity by the stigmas. Cool, rainy weather can wither the stigmas and dampen the vigour of the bloom.

If brief frost or long, cool rain has withered the stigmas, use the plants' growth as a guideline, because ultimately this is the most important criterion. You want the buds to reach a mature size, and to ripen for about another week. You do not want the buds to be left on the plant longer than necessary.

Ideally, harvesting should follow a period of warm, sunny weather. In northern and mountainous parts of the country, many tropical varieties will note flower until late in the season, when the weather has cooled and night-time frosts are threatening. Most mature plant can withstand mild frosts and continue to grow well if daytime temperatures are mild. In this case, let the plants mature, since formation of the buds is more important than the weather in determining potency. Watch the plants carefully, and harvest when the buds reach mature size. Marijuana killed by frost may smoke harshly, but potency does not seem affected. Well-formed buds should be picked if heavy rains are expected. Cannabinoids are not water-soluble, but gland heads will be washed away.

Barring a catastrophe, such as a long frost, death to Cannabis is usually not sudden. The plants will continue to grow, and may infact rejuvenate the next year if the stalks are left in the ground. But after the main bloom, the growth that follows is usually much less vigorous and sometimes forms abnormally. Leaves at this time are simplified, and have one blade. Later leaves are smaller, and tend to have entire margins (no serrations). Sometimes they are twisted or misshaped, as are the flowers that form along with them. This slow growth that follows the initial bloom will contribute little to the weight of the harvest. Additionally, this post-bloom growth is much less potent than the original bloom. Resin glands on these plant parts are feeble and poorly developed. When this abnormal growth forms, the time for harvesting is past. {See Figure 83.}

When a plant seems to persist in growing, and you are not sure bloom is past, the best procedure to follow is to try for a double harvest.

Double Harvests

Most marijuana plants take at least five months to reach maturity. Once the plant has reached maturity, it is forming its most potent marijuana, and should not be cut down completely. You can often induce the females to flower a second (and sometimes a third) time, especially if the plants are indoors or if the

weather is expected to stay mild for several more weeks.

To encourage a second bloom, first take the bulk of the harvest: all but the smallest buds, and most of the leaf. Some green leaves should be left on the plant to maintain the plant's growth. After harvesting, give the plants a thorough watering, and water with a soluble, complete fertiliser that provides a good supply of both N and P. This will encourage new growth and continued flowering.

Indoors, the best procedure is to treat the plants like a hedge. Cut all the plants back to equal heights, about two to three feet tall. Remove most of the grass, but again leave a few green leaves on the plant. Don't remove lower branches even if they are leafless, since these will sprout again. Lower the light system to the tops of the plants, and maintain the daily cycle at about 12 hours. The second crop of buds will be ready for harvest in four to eight weeks. With this system, the plants appear like dense hedges of buds. If the second crop of buds forms quickly, you should try for a third crop. Continue to fertilise the plants regularly, and watch for signs of magnesium deficiencies, which often show up when the plants have been growing for an extended time.

Double and triple harvests are one of the benefits of indoor growing. Although plants are relatively small indoors, the original harvest of buds can be triples in the next four months.

20.6 Potency and Decomposition

We have said that when buds are picked too late, the potency may decline because of decomposition of the cannabinoids, especially THC.

In section 21, Tables 26-29 give measured rates of decomposition of the major cannabinoids due to exposure to light and air. Light rapidly decomposes THC into unknown products (possibly polymers (122,164)). Light also converts CBD to CBS and CBC to CBL. Air (oxygen) slowly converts THC to the less active CBN. Conversion to CBN is hastened by higher temperatures.

Degradative processes do not occur as quickly in the living plant as when the cannabinoids are purified or in solution, as is shown by the data in Tables 27-30 in section 21 {Tables on disk only}. Resin glands seem to function well in storing the cannabinoids in dried plant material. However, the rates of decomposition in Tables 27 and 28 are for samples exposed to north light and a maximum of 80F temperatures. Temperature would be higher, and light stronger, under full sunlight.

Studies with fresh plant material usually show negligible CBN content in fresh marijuana from immature plants. When mature buds are tested, their CBN content is generally equal to at least five percent of their THC content. When growing temperatures are higher, such as in the tropics, CBN content can account for more than 20 percent of the original THC. Even if we assume a low figure, such as five percent conversion of THC to CBN, there is actually a much greater decline in THC content because of the simultaneous degradation of THC by light.

When the slow rate at which THC oxidises to CBN is considered, five percent decomposition in a period of less than two months represents considerable exposure of the THC to air, and most of this exposure occurs in the last critical weeks when the resin glands begin to degenerate. Plates 8 and 11-13 show the condition of the resin glands on several different kinds of marijuana.

Stalked glands that cover the female flower bracts sometimes rupture or secrete cannabinoids through pores in the glands head. Secretion is not a continuous flow, but more of an emptying of the glands' contents. At this time, gland heads may dehisce. Also, because of their abundance and raised positions, resin glands on the female bracts are exposed to strong sunlight and possible physical damage. These conditions may explain the significant decline in potency of buds that are overripe.

Leaves are also affected by decomposition of the cannabinoids, but not as quickly or seriously as the buds, probably because the resin glands on the leaves are most numerous on the undersurface, where they are somewhat protected from light. These glands rarely rupture or secrete cannabinoids. Often they are intact, clear, and apparently unchanged for many weeks on the living plant.

As the plates show, one can, with the naked eye, see the glands change colour, from colourless or white to golden, and then to reddish or brown. THC is colourless. If the colour changes of the resin do indicate decomposition of THC, then decomposition in the stalked glands that cover the buds can be considerable.

We have smoked buds that seemed to lose about half their potency when left on the plant for an addition three weeks. Colour changes are after the fact. If many of the glands are beginning to brown, the grass should be harvested.

20.7 Timing the Harvest

Many growers will disagree with us on when the best time is to harvest the buds (female plants). When the plants are left in the ground, and are alive but past the main bloom, the resinous qualities of the plant may become more apparent. The bracts and tiny leaves may swell in size, and the leaves feel thicker. The coating of resin glands will change colour. Leaves often yellow and fall form the plant. Much of the green colour in the flowering buds may also be lost. Harvests of these buds more closely resembles commercial Colombian grass than typical homegrown. The resin content of the dried buds may be higher, and the grass will smoke more harshly than if the buds were younger when picked. You may prefer these qualities in your grass, and some growers insist this grass is stonier. We feel that the grass will give you the highest high when it is picked as described previously. Smoking is a personal experience, and you should try different approaches and come to your own conclusions.

The first time you grow marijuana is largely a learning experience. Most growers can't wait to start their second crop, because they are certain that they'll improve on both the quantity and the quality of their crop, and this is usually true. The wise grower will not put all his proverbial eggs in one basket. It is a good idea to monitor potency by taking samples every few days when harvest time is drawing near, just as such monitoring is for deciding when to harvest growing shoots during vegetative growth.

In any garden, some of the plants will mature sooner than others. Use the plant(s) that is earliest to mature to decide at what point in its development the plant reaches maximum potency. This finding then serves as a guide for harvesting the rest of the plants.

Try to use buds from approximately the same position on the plant each time you sample. Take only enough to make a joint or two. The more you standardise your testing (and this includes your smoking evaluation), the more accurate your results may be.

20.8 Final Harvesting

The time of harvest is a time of joy. It is also a time for caution. Unless the safety of your garden is assured, you will want to harvest quickly, quietly and as efficiently as possible. Ideally, each plant is harvested as it matures, but some of you will have to harvest all at once.

It is best to take cardboard boxes or large, sturdy bags to carry the harvest. You want to harvest the plants with as little crushing or damage to the flowers as possible.

Bring a strong knife, heavy shears, or clippers for cutting the stalks. The quickest way to harvest is to cut each plant at its base. Once the plants are on the ground, cut the stalks into manageable lengths for boxing or bagging. Separate large branches as needed for packing.

The bagged or boxed material should be moved to the curing or drying area as soon as possible. If you let the plants sit in the trunk of a car or in plastic bags, they will start to ferment and small in less than a day.

Chapter 21
AFTER THE HARVEST

Once the marijuana plant is harvested, it ceases to produce cannabinoids and resins, and the main changes in potency that occur are degradative. However, when the material is handled carefully, dried or cured properly, and then stored well, little degradation will occur. During drying or curing, the resin content may seem to increase, as the plant's tissues shrink away from their resinous coating.

More than 70 percent of the fresh weight of the plant os water. Drying is done to evaporate most of this water, so the marijuana will burn evenly and smoke smoothly. Additionally, the cannabinoids in fresh plant material are mostly in the acid forms, which are not psychoactive. The acid cannabinoids decarboxylate (they lose the gas, carbon dioxide) during the drying or curing processes, which convert them to their psychoactive neutral forms. Decarboxylation is complete if the marijuana is actually smokes. For this reason, no special procedures are needed to decarboxylate the marijuana unless it will be eaten. In that case, the recipe should include a period of dry heating. The heat converts the cannabinoids to their psychoactive neutral forms, and also melts the sharp-pointed cystolith hairs that cover leaves, stems and petioles. Cystolith hairs can cause stomach pains if you eat uncooked marijuana or chew on raw marijuana, which we strongly advise you not to do.

Commercial marijuana us usually composed of just the flower tops (colas), which have been stripped, manicured, cured, and dried. Homegrowers often do not cure their crop before drying, and if the smoke is smooth, there is no reason not to dry it directly. But harsh-smoking marijuana can be cured so that the smoke is smoother. Curing has little affect on potency when done properly.

21.2 Stripping

Stripping, the removal of large leaves, is usually done soon after harvesting. Fan leaves are stripped because they are much less potent than the colas that they cover, and do not cure as well as the prime material. In commercial growing areas, the fan leaves are often stripped in the field and form a green manure. But fan leaves are sometimes quite potent, especially if they are recent growth. The lower leaves are usually weak, but they can be used in cooking or concentrated in an extract.

The easiest time to strip fan leaves is after they have wilted, because they are easier to pull off when they are limp then when they are turgid. Wilting takes place in less than an hour if the plants are in a well-ventilated space. Plants placed in a plastic bag in a cool area may take a day or more to wilt.

Some growers leave the fan leaves on until the plants have dried. After the buds are removed, they strip the remaining leaves by running their (gloved) hands from the base of stems and branches toward their tips. The fan leaves disintegrate into shake.

21.3 Grading and Manicuring

Grading and manicuring are important steps in preparing fine grass. Grading is done by separating the plants according to variety, sex, and the particular stash uniform, and the quality of the better grades is not diluted. Plant parts are usually graded as follows: main top colas, small side colas, immature buds, leaves accompanying flowers, and fan and stray leaves. This is important, because the differences in potency will be considerable. For instance, the buds on a Colombian homegrown will be top quality, but the lower leaves will be more like a low-grade commercial Mexican.

Manicuring is done to remove the extraneous leaf from the colas. First the large fan leaves are stripped. The exposed colas are then trimmed with scissors to remove the ends of leaves that stick out from the colas. Plants should be manicured and (usually) graded before drying, since dried material crumbles into shake when handled. Also, leaves dry much more quickly than buds, and different plant parts cure at their own rates.

Male flowers are often treated as a novelty by growers, who make individually rolled sticks from them, as follows. Hang the plants upside down; the leaves will wilt and hang down, covering the male flower clusters. Then roll each cluster within its leaves between the palms of your hands, to compress the cluster into a joint-shaped mass. Dry the "stick" in a warm dark place. Rolling the grass ruptures many of the glands; so dried sticks should be stored carefully until each is used.

Hashish

When you handle your crop, you may notice a resin build-up on your hands and the tools you are using. This resin can be collected by rubbing and scraping it into a ball. It makes a quality hash that is several times as concentrated as the grass.

Small quantities of hash can be made by rubbing resinous plant parts across a thin, fine mesh screen. The resin is then scraped off the screen and rolled into finger shapes. Hash can also be made by thrashing fresh plants over a mesh screen inside an enclosed box whose floor is lined with sheet plastic. A box about one yard square is a suitable size. On one side of the box a hole is made large enough for the colas to be shaken by hand. In this way, the resin glands are knocked loose, but are contained by the box and settle on the plastic.

Plastic or paper should be placed beneath the marijuana during manicuring, grading, or drying. Besides fallen grass, a considerable amount of glands and fine shake can be caught and compressed to a hash-like mass.

21.4 Curing

Curing is a process employed to naturally enhance the bouquet, flavour, and texture of marijuana. Curing does not lower potency when done correctly, although poor curing methods often result in some less of THC.

Curing is not an essential procedure, and many growers prefer the "natural" flavour of uncured grass. Sweet sinsemilla buds usually are not cured.

Curing is most successful on plants which have "ripened" and are beginning to lose chlorophyll. It is less successful on growing tips and other vigorous parts which are immature. These parts may only lose some chlorophyll.

Curing proceeds while the leaf is still alive, for until it dries, many of the leaf's life processes continue. Since the leaf's ability to produce sugars is thwarted, it breaks down stored starch to simple sugars, which are used for food. This gives the grass a sweet or earthy aroma and taste. At the same time, many of the complex proteins and pigments, such as chlorophyll, are broken down in enzymatic processes. This changes the colour of the leaf from green to various shades of yellow, brown, tan, or red, depending primarily on the variety, but also on growing environment and cure technique. The destruction of chlorophyll eliminates the minty taste that is commonly associated with green homegrown.

There are several methods of curing, most of which were originally designed to cure large quantities of tobacco. Some of them can be modified by the home grower to use for small marijuana harvests as well as large harvests. The methods used to cure marijuana are the air, flue, sweat, sun, and water cures.

Air Curing

Air curing is a technique developed in the United States for curing pipe and cigar tobacco. It was originally done in specially constructed barns made with ventilator slats which could be sealed; a small shed or metal building can easily be adapted for this use. However, this method of curing works only when there is enough material to keep the air saturated with moisture.

Wires are strung across the barn, and the marijuana plants or plant parts are hung from them, using string, wire twists, or the crooks of branches. The plants material should be closely spaced, but there should be enough room between branches (a few inches) so that air circulates freely. The building is kept unventilated until all the material loses some chlorophyll (green colour). This loss occurs rapidly during warm sunny weather because heat builds up, which hastens the cure. In wet or overcast weather, the temperature in the chamber will be cooler, and the process will proceed more slowly. If these conditions last for more than a day or two, unwanted mould may grow on the plants. The best way to prevent mould from forming is to raise the temperature to 90F by using a heater.

After the leaves have lost their deep green and become pale, the ventilator or windows are opened slightly, so that the temperature and humidity are lowered and the curing process is slowed. The process then continues until all traces of chlorophyll are eliminated. The entire process may take six weeks. Then the ventilators are opened, and an exhaust fan installed if necessary, to dry the material to the point that it can be smoked but still is moist, that is, bends rather than crumbles or powders when rubbed between thumb and forefinger.

Flue Curing

Flue curing differs from air curing in that the process is speeded up by using an external source of heat, and the air circulation is more closely regulated. This method can be used with small quantities of material in a small, airtight curing box constructed for the purpose. Large quantities can be hung in a room or barn as described in Air Curing.

A simple way to control the temperature when curing or drying small amounts of marijuana is to place the material to be cured in a watertight box (or a bottle) with ventilation holes on the top. Place the box in a water-filled container, such as a pot, fish-tank, or bathtub. The curing box contains air and will float. The water surrounding the box is maintained at the correct temperature by means of a stove or hotplate, fish-tank or water-bed heater, or any inexpensive immersible heater. Temperature of the water is monitored.

With the marijuana loosely packed, maintain water temperature at 90 degrees. After several days, the green tissue turns a pale yellow-green or murky colour, indicating yellow or brown pigments. Then increase temperature, to about 100 degrees, until all traces of green disappear. Raise the temperature once again, this time to 115 degrees, until a full, ripe colour develops. Also increase ventilation at this time, so that the marijuana dries. Plants dried at high temperature tend to be brittle; so lower the temperature before drying is completed. This last phase of drying can be done at room temperature, out of the water bath. The whole process takes a week or less.

Marijuana cured by this technique turns a deep brown colour. Immature material may retain some chlorophyll and have a slight greenish cast. Taste is rich yet mild.

Sweat Curing

Sweat curing is the technique most widely used in Colombia. Long branches containing colas are layered in piles about 18 inches high and a minimum of two feet square, more often about ten by fifteen feet. Sweat curing actually incorporates the fermenting process. Within a few hours the leaves begin to heat up from the microbial action in the same way that a compost pile ferments. Then change in colour is very rapid; watch the pile carefully, so that it does not overheat and rot the colas. Each day unpack the piles, and remove the colas that have turned colour. Within four or five days, all the colas will have turned colour. They are then dried. One way to prevent rot while using this method is to place cotton sheets, rags, or paper towels between each double layer of colas. The towels absorb some of the moisture and slow down the process.

Sweat curing can be modified for use with as little marijuana as two large plants. Pack the marijuana tightly in a heavy paper sack (or several layers of paper bags), and place it in the sun. The light is converted to heat and helps support the sweat.

Another variation of the sweat process occurs when fresh undried marijuana is bricked. The bricks are placed in piles, and they cure while being transported.

A simple procedure for a slow sweat cure is to roll fresh marijuana in plastic bags. Each week, open the bag for about an hour to evaporate some water. In about six weeks, the ammonia smell will dissipate somewhat, and the grass should be dried. This cure works well with small quantities of mediocre grass, since it concentrates the material.

Sun Curing

A quick way to cure small quantities of marijuana os to loosely fill a plastic bag or glass jar, or place a layer between glass or plastic sheets, and expose the material to the sun. Within a few hours the sun begins to bleach it. Turn the marijuana every few hours, so that all parts are exposed to the sun. An even cure is achieved in one to two days {(see Plate 16)}. Some degradation of THC may occur using this method.

Water Cure

Unlike other curing methods, the water cure is performed after the marijuana is dried. Powder and small pieces are most often used, but the cure also works with whole colas. The material is piled loosely in a glass or ceramic pot which is filled with luke-warm water. (When hot water is used, some of the THC is released in oils, which escape and float to the top of the water.) Within a few hours many of the non-psychoactive water-soluble substances dissolve. An occasional gentle stirring speeds the process. The water is changed and the process repeated. Then the grass is dried again for smoking.

THC is not water-soluble; so it remains on the plant when it is soaked. By eliminating water-soluble substances (pigments, proteins, sugars, and some resins), which may make up 25 percent of the plant material by weight, this cure may increase the concentration of THC by up to a third.

Marijuana cured by this method has a dark, almost black colour, and looks twisted and curled, something like tea leaves. The water cure is frequently used to cure dried fan leaves and poor-quality grass.

21.5 Drying

Living marijuana leaves are 80 percent water; colas are about 70 percent water. Marijuana dried for smoking contains only eight to 10 percent water, or about 10 percent of the original amount. There are several methods used to evaporate water; these have little effect on potency, but can affect the taste, bouquet, and smoothness of the smoke. Generally, the slower the dry, the smoother the taste. Excess drying and drying methods that use heat will evaporate some of the volatile oils that give each grass its unique taste and aroma.

Grasses which are dried as part of the curing process usually have a smooth, mild taste, because of the elimination of chlorophyll and various proteins. Cured marijuana may also be a little sweeter than when first picked, because the curing converts some of the plant's starch to simple sugars.

Some grasses are tasty and smooth-smoking when they are dried without curing, especially fresh homegrown buds which retain their volatile oils and sugar. Many homegrowers have acquired a taste for "natural" uncured grass, with its minty chlorophyll flavour; such marijuana is dried directly after harvesting. {Figure 89, Male plants drying on a tree. Cheesecloth holds loose leaf for drying.}

Slow Drying

Slow drying is probably the method most commonly used to dry marijuana. Because of the slowness of the dry, a slight cure takes place, eliminating the bite sometimes associated with quickly dried grass.

There are many variations of the technique, but most commonly whole plants or separated colas are suspended upside down from a drawn string or from pegs on a wall in a cool dark room, closet, or other enclosed space. A large number of plants may take a week or two to dry. The drying time for small numbers of plants can be increased (for a slight cure) by placing the plants in large, open paper sacks that have ventilation holes cut in their sides. The drying room should have no heavy drafts, but mould may form on the plants if the air is stagnant. If weather is rainy or the air humid, increase ventilation and watch for any mould. Plants should be dried quickly under moderate heat if any mould appears.

Many experienced growers prefer slow drying to curing. There is little chance of error with this method, and buds usually smoke smooth and develop a pliable consistency. Slow-dried ripe buds retain their delicious, sweet aroma and taste.

Fast Drying

The fast dry-method produces a harsher smoke than slow drying, but it is often the most convenient method to use. The plants are suspended in the same way as for slow drying, but the temperature in the drying area is increased to between 90 and 115 degrees, often by means of electric or gas heater. The drying area is kept well-ventilated with a fan. As the plants dry, they are removed from the drying area. By this method, plants in a tightly packed room can be dried in less than four days, but the exhaust will contain the deliciously pungent odour of drying marijuana.

Indoor growers often hang plants to dry over radiators or stream pipes. Leaves are dried by placing them on a tray over a radiator or on top of the light fixture.

Marijuana that is fast-dried retains its original green colour and minty taste.

Oven Drying

Oven drying is often used by gardeners to sample their crop. Small quantities of material can be quickly dried by being placed in a 150 to 200 oven for about 10 minutes. Larger quantities can be dried in trays that contain a single layer of material or in a dehydrator. Oven-dried and dehydrator-dried marijuana usually has a harsh taste and bite, and loses much of its bouquet. The method is often used to dry marijuana which has been cured and dried but is too moist to smoke, or to dry marijuana which is to be used for cooking or extractions. It is an adequate method for obtaining dry material for testing and emergencies, but the main harvest should not be dried in this way. Oven drying works best with leaves. When leaves are dried together with buds or shoots, remove the material from the oven periodically, to separate the faster-drying leaf material (before it burns) from the slower drying buds. One way to do this is to place all the material on a wire screen over a tray. Every few minutes rub the material across the screen. Dried material falls unto the tray and is removed from the oven. Repeat until all the material has dried.

Oven curing works well when closely watched. Dried marijuana that is left in the oven will lose potency quickly. Any time the marijuana begins to char, most of the potency will already have been lost. This should not be a problem unless you are careless, or allow the temperature to go above 200 degrees.

Sun Drying

Some growers dry their crops right in the field. There are many methods of sun drying. In Oregon, some growers break the main stem about two feet from the ground. The leaves and buds dry gradually, since they are still partly attached to the plant. Other growers spread burlap and cover it with plants left to dry. Fan leaves are left on the plants to protect the drying buds from the sun. The grass is manicured after drying. Growers in Arizona shade drying plants with cheesecloth.

Sun-dried marijuana usually has a taste similar to that of oven-dried. Often the sun bleaches it slightly but also destroy some of the delicate bouquet. Prolonged exposure to the sun will decrease potency, although there is no noticeable loss if drying is done quickly.

Dry Ice

Many homegrowers have written to us that the dry-ice cure increases the potency of marijuana considerably, and we would be remiss not to mention it.

Dry ice is frozen carbon dioxide. When it melts (sublimates), it turns from a solid directly into a gas. This gas absorbs some moisture from the frozen marijuana and partially dries it.

There are many variations of the dry-ice method. Fresh or partially dried material is usually used, although some enthusiasts claim that the cure also works with dried material. The marijuana is placed in a coffee can or similar container with a lid, along with at least an equal volume of dry ice. Puncture the lid so that the gas can escape as it evaporates. Place the can in a freezer to prolong the evaporation process. When the dry ice is gone, the grass is dried, but still moist.

Some growers claim that simply freezing the grass increases potency. They often freeze fan leaves or

other less-potent material for a couple of months before smoking it. This is said to work only with fresh (wet or dried) grass.

21.6 Fermentation

When vegetation dries, the individual cells which maintained life processes die. But marijuana can still be conditioned by means of fermentation. Fermentation is the process in which microbes and plant enzymes break down complex chemicals into simpler ones, mainly starch and sugars into alcohol and simple acids. In the process chlorophyll is destroyed, giving the material a more ripened appearance. If the fermentation is stopped early, the marijuana has a sweeter taste because of the sugars which the ferment produced.

Fermentation occurs when the moisture content of the marijuana is raised above 15 percent and the temperature is above 60 degrees. The more tightly packed the material, that faster the ferment proceeds. The rate of ferment is controlled primarily by varying the moisture content, but each batch proceeds at its own rate because of differences between plants in nitrogen content. (Nitrogen is necessary to maintain fermenting bacteria.) The process is delicate; should the ferment proceed too rapidly, the marijuana may be converted to compost. Watch the fermentation closely. After the desired colour or flavour (from a dried sample) is reached, dry the grass quickly to stop the process.

During fermentation, flavourings can be added to give the marijuana a spicy aroma. Such spices as cinnamon, cloves, ginger, mace, sage, or vanilla are placed between the fermenting material. Orange, lemon, or lime peels are also used. About half an ounce of spice or four ounces of peel are used for each cubic foot of material to be fermented. The spices are wrapped in cloth sachets. The citrus peels are strung. They can be placed between the layers of marijuana.

There are two types of fermentations: self-generating and forced. They are best used with leaves or immature plants.

Self-Generating Fermentation

Self-generating fermentation proceeds rapidly only when there is enough material to make a heap at least one cubic yard large. When smaller quantities are used, too much of the heat generated by the bacteria is dissipated, so that the process is slow and is more properly considered aging.

Place the material in a large container or in a pile with a tarpaulin placed over it, and lightly spray it with a mister if it is dry. Let the pile heat up for a few days, and then break it down. If it is repacked, the marijuana will develop a dull matte appearance and lose its sugars. IF the process is allowed to proceed even further, the marijuana will disintegrate.

Forced Fermentation

Forced fermentation can be used with small quantities of material. It requires an enclose chamber in which heat and humidity can be regulated.

Pack the marijuana loosely in a kiln or other chamber, and raise the temperature to 135 degrees. Maintain humidity at 75 percent. Check the progress of the ferment periodically. Within a week the ferment should be completed. During this ferment there is a release of ammonia compounds, resulting in some foul odours, but upon completion of the ferment and drying, the marijuana should smoke sweet and mellow.

21.7 Storage

THC is degraded by both heat and light. Table 26 shows results of an experiment conducted at the University of Mississippi, in which marijuana was stored under varying temperature conditions171. These results indicate that marijuana stored at room temperature (72) or below, and in darkness for up to two years will lose only an insignificant amount of its original potency; whereas marijuana stored in darkness at 97 or above will lose almost all its potency within two years.

In another experiment,164 Fairbairn stored dried marijuana at different temperatures in both light and dark conditions. The samples in light were exposed to a north-facing windows (no direct sunlight). The results are shown in Table 27.

Fairbairn also performed an experiment to discover the effect of air on THC164. Freshly prepared Cannabis resin was stored as a loose powder, a compressed powder, and an unbroken lump for one year at 68 degrees F (about room temperature). Samples were stored under two conditions: in light and air, and in darkness and air. The results are shown in Table 28.

Fairbairn experimented further with pure cannabinoids and extracts of marijuana dissolved in petroleum ether, chloroform, and ethanol (alcohol)165. The results, in Tables 29 and 30, show that the THC and CBD in solution are much more unstable than when they are left in marijuana, especially if they are held by the plant in undamaged glands, where they are protected from exposure to air and, to some degree, light. Crude extracts seem more stable than highly refined cannabinoids, especially CBD, which is very unstable in refined solutions.

Extract makers and purchasers should limit the exposure of the solution to light and heat as well as to air. Oils and extracts should be kept refrigerated in opaque, sealed container. Notice that THC is almost completely degraded in a few weeks when it is held in solution and exposed to light. Red oil, hash oil, and honey oil must be stored in light-tight containers to preserve potency.

From the tables, you can see that light is the primary factor that causes decomposition of THC. The decomposition products are unknown, but are suspected to be polymers or resins. We also do not know whether the rate of decomposition would be faster in direct sunlight.

Air (oxygen) acts much more slowly to convert THC to CBN. Decomposition of THC to CBN is not significant unless temperatures are in the nineties or higher. However, such high temperatures can occur in grass that is packed before it is properly dried. The moisture that is left supports microbial activity, which heats the grass internally, as occurs during certain types of curing. Potency of cured grass is not lowered significantly when the cure is done properly and when the buds are left intact during the process.

The figures for powdered and compressed grass in Table 28 show that both light and air cause rapid decomposition when the resin is exposed through breaking of the resin glands. Intact resin glands appear to function well in storing the cannabinoids. For this reason, it is important to handle fresh and dried grass carefully, in order not to crush the material and thus break the glands, especially in the buds, which have a cover of raised resin glands. Most well-prepared marijuana will have intact, well-preserved buds.

The best place to store marijuana is in a dark container in a refrigerator or freezer. Cannabis should be stored uncleaned, so that the glands containing the THC are not damaged, since damage causes their precious contents to be exposed to light and air. Marijuana should be cleaned only when it is about to be smoked.

Many growers place a fresh lemon, orange, or lime peel in with each lid of stored grass. The peel helps to retain moisture, which keeps the buds pliable, and also gives the grass a pleasant bouquet.

Most growers take well-earned pride in the quality of the marijuana that they grow. By supplying yourself with an herb which may play an important role in your life, you gain a feeling of self-sufficiency that can be infectious.

Since your homegrown is well-tended and fresh, it has a sweet flavourful taste, far superior to that of commercial grass. And there need be no fear of contamination from herbicides, pesticides, adulterants, or other foreign matter. By growing your own, you come to the pleasant realisation that you are free from the vagaries and paranoia of the marijuana market - not to mention how little a home garden costs. All of these feeling can add up to a very heady experience.

In a time of quiet contemplation, you might also reflect on the experiences that brought you this wondrous herb from a tiny seed. There is a tradition of mutual nurture and support between humanity and this plant

that goes back 10,000 years.

You are now part of this continuing tradition.

As you probably realised while reading this book, some of the practical information came to us through letters from growers. We appreciate these letters and will continue to refer to them when we update and improve future editions of the Marijuana Grower's Guide. We would also like to hear ideas, criticisms, and feedback from our readers. Other research material and copies of professional research are also welcome.

Wishing you a Happy Harvest,
Mel Frank
Ed Rosenthal

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